
PROBLEM SOLVING AND TRAINING GUIDE FOR SHIPYARD INDUSTRIAL ENGINEERS

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CORPORATE-TECH PLANNING, INC.

PROBLEM SOLVING AND TRAINING GUIDE

FOR

SHIPYARD INDUSTRIAL ENGINEERS

TASK EC-19

Submitted to:
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Date: June, 1986

This project is managed and cost-shared by Corporate-Tech Planning, Inc. for the National Shipbuilding Research Program. The program is a cooperative effort of the Maritime Administration's Office of Advanced Ship Development, the U.S. Navy, the U.S. shipbuilding industry, and selected academic institutions.

Foreword

FOREWORD

The purpose of this Guide is to assist Industrial Engineering Department employees to solve shipyard problems more effectively. The Guide does this by organizing or codifying information so that a shipyard problem may readily be related to a source of assistance. This assistance is provided by several indexes, a bibliography, a training guide, a curriculum, and a list of schools.

The Naval Shipyards have been ahead of the commercial yards in hiring and training degreed Industrial Engineers. The majority of the degreed Industrial Engineers in commercial yards are to be found at the larger yards although that picture seems to be changing. Most shipyards rely on skilled technicians promoted from the trades and upon outstanding people from other disciplines. These people have performed very well, combining their native intelligence with waterfront knowledge to accomplish many industrial engineering tasks. It is to be hoped that the Guide will be specially helpful in supplying useful training to these technicians.

The Guide is organized into the following five sections:

- 1.) INDEXES which are the link between the information in the other sections.
- 2.) BIBLIOGRAPHY which lists book and other sources of knowledge.
- 3.) TRAINING GUIDES which suggest portions of the curriculum for each of seven audience groups.
- 4.) CURRICULUM which identifies the subjects which Industrial Engineers will find helpful in solving shipyard problems.
5. SCHOOLS which teach Industrial Engineering or ship repair and construction.

The figure on the next page illustrates these five sections and the connections between them.

The Index starts with a list of shipyard problems in seven categories. For each problem there is a Curriculum reference, and a Bibliography reference.

The Bibliography includes its own index identifying the subjects, authors and title. In addition there is a section which includes useful guidance for finding additional information.

The Training Guides suggest material in the curriculum which is appropriate for each of seven groups within the shipyard. It is hoped that the management of the Industrial Engineering Department will find this guidance useful when called upon to increase the knowledge about industrial engineering of some shipyard group.

The Curriculum is seen especially as a tool to identify new knowledge which will expand the areas in which the technician will be able to perform well. The Curriculum is broad enough to help almost anyone to increase his appreciation of the benefits of applying Industrial Engineering methods to shipyard problems. The Curriculum is divided into two broad sections, the first one dealing with Industrial Engineering Skills and the second with Applications of these Skills to shipyards. The Skills Section is organized into five modules and the Applications Section is organized into four modules.

The men and women who have expanded personal knowledge from their parent discipline to knowledge of the Industrial Engineering profession have served as an inspiration and example for the industry. Their contributions to the shipyards is hereby acknowledged. It is to be hoped that their example will inspire others to strive for this knowledge.

My personal thanks go to the Managers, Engineers and Technicians who provided much of the information used in the preparation of this Guide and for their insight into the needs of the industry.

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HOW TO USE THE PROBLEM SOLVING AND TRAINING GUIDE TO HELP WITH SHIPYARD INDUSTRIAL ENGINEERING PROBLEMS

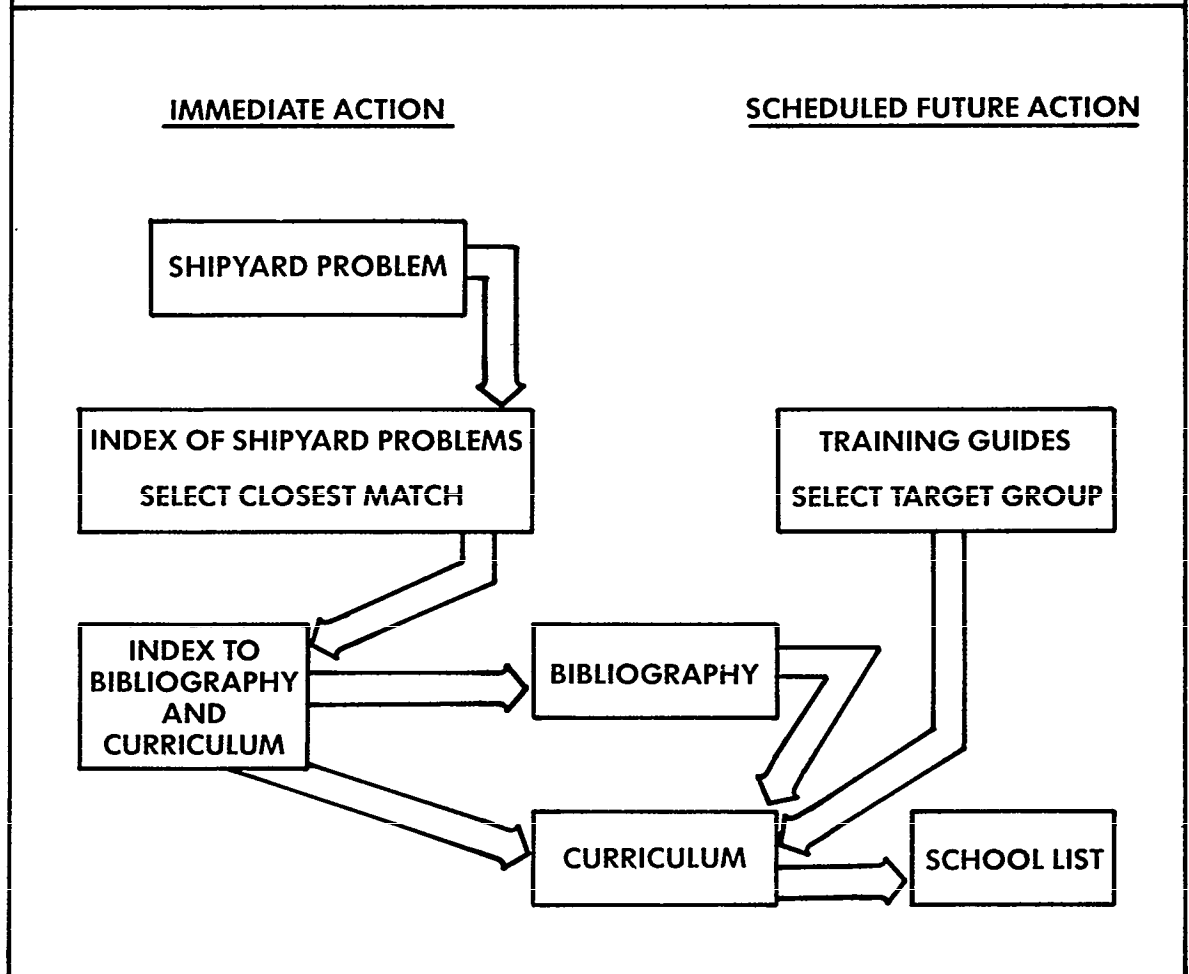


FIGURE 1. RELATIONSHIP OF VARIOUS COMPONENTS OF THE GUIDE. DOCUMENTS ARE SHOWN IN UPPER CASE LETTERS.

INDEX OF SHIPYARD PROBLEM AREAS

CONTENTS

- I. Introduction to the Index of Shipyard Problem Areas
- II. How to Use the Index
- III. Index

I. Introduction to the Index of Shipyard Problem Areas

Most appropriately, the first section of the Problem Solving and Training Guide lists representative problems to be solved. For each entry or problem on the list, a corresponding reference has been made to the Bibliography and to the Curriculum. This Index does not purport to include all shipyard problems to which an Industrial Engineer will be asked to apply his professional skills. The Index is intended, however, to be encompassing enough so that the user will be guided to an appropriate information source in the Bibliography and Curriculum. Experience has shown that many valuable solutions are the result of the Industrial Engineer selecting and combining elements of several techniques or approaches to resolve the problem identified.

II. Using the Index

Shipyard Problems shown in the Index have been grouped into seven categories so that similar subjects will be located in close proximity to each other. In this way, the user will be directed to the appropriate reference material even though the Industrial Engineer may be using similar but different key words. The seven categories shown in the far left column of the Index are:

PROBLEM CATEGORIES

C = COMMUNICATIONS

F = FACILITIES

M = MATERIALS

P = PLANNING AND PRODUCTION CONTROL

Q = QUALITY

R = RATES OF PAY

S= SAFETY

The column in the Index titled BIOGRAPHY REFERENCES shows the identification number of an appropriate reference in the Bibliography Section. The column titled CURRICULUM REFERENCES identifies the appropriate Curriculum Module as a Roman Numeral (I to IX) and the most relevant section within that Module is referenced by an Arabic Number (1 to 7).

III. INDEX OF SHIPYARD PROBLEM AREAS WITH REFERENCE TO USEFUL INFORMATION

CAT	SHIPYARD PROBLEM AREA	BIBLIOGRAPHY REFERENCES	CURRICULUM REFERENCES
c	Data Base Coordination & Integration	5 15 20	IV-5, V-4 VI-7, 9, VII-2, 3,4,5, VIII-2, 3, IX-2, 3, 4
c	Inadequate or Conflicting Documentation	5 15 20 245 250	IV-5, V-4, VII-2, 3,4,5,6,7,8,9, VII-3, IX-2, 3,4
c	Information to Craftsman	5 245 250 255 275 280 285 290 300 415 425 435 450 455	V-1, 2 ,3, VII-1, 9
c	Records Maintenance	5 15 250 260 345 395 400 415 450	IV-5, V-1, 4
c	Report Writing	275 280 285 290 295 300	V-1
F	Cost-Benefit Analysis	91 255 260 265 270 271 600	IV-4
F	Excessive Equipment Downtime	15 25 85 90 255	II-1, 2, IV-1, 2, 4
F	Facilities Design	245 250 305 310 315 320 325 330 335 340 370 375 390 475 490 505 520	III-2, IV-4, VII-2, 3, 5, 6, 7, VIII-4
F	Maintenance	315 320 325 341 342 475 490 500 505 555	IX-2, 3, 4
F	Pay-back Calculations	255 260 265 270	IV-4, VII-5
F	Plant Accounting Systems	15 255 256 271	IV-4
M	Controlling Work Scope	400 405 410 415	VII-1, 2, 9, VIII-1, 2, 3 ,4, 5
M	Crib Stock-Outs	65 70 400 405 410 415	III-1, IV-1, 2, VII-3, 4, 8, 9, IX-2,4
M	Determine Best Method	21 25 30 40 36 40 45 50 55 86 87 100 255 260 265 270 550 555 865	III-1, 2, 3, 4, IV-2 ,4, V-4, VII-2, 3, 5, 6, 7, 8, 9, IX-2
M	Identify Incorrect Method Use	65 70 395 400	VIII-3, IX-3, 4
M	Late Material	65 70 400 405 410	VII-8, VIII-4, 5, IX-3
M	Make/Buy Decisions	255 260 265 270 350 365 650	IV-4, VII-3, 4, 5, 7, 8

INDEX OF SHIPYARD PROBLEM AREAS WITH REFERENCE TO USEFUL INFORMATION

CAT	SHIPYARD PROBLEM AREA	BIBLIOGRAPHY REFERENCES	CURRICULUM REFERENCES
M	Material Flow	345 350 355 360 400 350 430 435	VII-2, 5, 7, 8
M	Material Handling Machinery	305 341 345 355 375 510 520 655	VII-5
M	Warehousing	345 350 355 360 365 400	IV-4, VII-5, 8
P	Assuring Correct Method	5 10 15 20 255 260	III-1, VIII-2, 3,4,5
P	Auditing Results	50 55 195 205 210 220 225 235	V-4, VIII-1, 3
P	Delay Waiting for Support	65 70 400 405 425 430 435	VII-2, VIII-3, 4, IX-2, 3, 4
P	Excessive Travel by Craftsmen	25 30 35 36 40 45 50 55 70	III-1, IV-1, 2
P	Idle Time	65 70	III-1, IV-1, 2, VII-3 ,4, 8, 9, VIII-1, 3
P	Inefficient Process Flow	91 305 320 325 330	III-1, 2, VII-2, 3 ,4, 9, VII-1
P	Progress Measurement	92 255 260	III-1, VIII-3
P	Schedule Adherence	255 260	VIII-2, 3 ,4, 5, IX-2
P	Product Lanes	25 30 35 40 45 50 55 305 310	IV-4, VII, 1, 2, 3 ,4, 5, 7, 8, 9
Q	Excessive Rework	394 395	III-1, 2, VII-2, 7, VIII-3
Q	Quality Failures	394 .395	V I I - 7
R	Incentive Pay	25 30 35 36 40 45 50 55 60 75 80 85 90 95 100	III-1, 2, 3, 4, IV-4, V-4, VII-3, 5, 6, 7, 9, VIII-3 IX-2, 4
S	Unsafe Act or Equipment	370 375 380 385 390	VII-5, 6

C = COMMUNICATIONS
 F = FACILITIES
 M = MATERIALS
 P = PLANNING/PRODUCTION CONTROL
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 R = RATE OF PAY
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**BIBLIOGRAPHY FOR CURRICULUM
IN INDUSTRIAL ENGINEERING
FOR SHIPYARDS**

CONTENTS OF BIBLIOGRAPHY

Introduction to Bibliography

Suggested Minimum Library

Main Sequence

- Introductory and General Works
- Work Measurement
- Predetermined Time Standards
- Mathematics for Industrial Engineering
- Electronic Assistance
- Financial Analysis
- Data Presentation
- Equipment and Facilities
- Purchasing, Warehousing, Materials Handling
- Safety
- Quality
- Planning, Scheduling, and Production Control
- Networking
- Support Services

Miscellaneous Research Sources

Standard Terms for Use in Library Searches

Finding Information Online

Videotapes

Publisher's Catalogs

Finding Out about Courses

Author/Title Index to Bibliography

INTRODUCTION TO BIBLIOGRAPHY

This bibliography is a list of books and other references that may be of interest and practical use to shipyard personnel engaged in industrial engineering. We have attempted to find the best and most useful sources, based on considerations of cost, widespread availability in libraries or bookstore special-order channels, and the real needs of people in the shipyards.

Users of this bibliography wishing to locate references should check first with their company libraries and local public libraries. The libraries of universities which offer courses in management and engineering usually own some of these materials, too. Most company and university libraries, and most sizable public libraries have professional staff who can aid in locating the materials listed here.

Users who wish to purchase items listed here will note that publisher addresses and 1985 prices have been provided; but users should also be aware that most bookstores (of all types: chain, independent, college) can quickly obtain special order books at list price through national distribution channels. The exception is government documents, which are best ordered directly from the source.

To facilitate purchasing, we have included an ISBN (International Standard Book Number) for each book currently available from the publisher or through bookstore special-order. (For government publications, there is no ISBN; the government uses instead a stock number, abbreviated 'S/N'.) For the handful of out-of-print books we have listed, the OCLC (Online Computer Library Center) number has been included, to facilitate interlibrary loan requests.

How is this bibliography structured? First, we list a handful of general works which serve several different modules, as well as being good introductory sources. Next, we list a long sequence of more specialized works pertaining to topics treated in the curriculum. The sequence follows the general sequence of topics treated in the curriculum. After that, we list a number of miscellaneous references which are helpful to people fulfilling the industrial engineering role in a shipyard. Following the main portion of the print bibliography, we provide information on standard library search terms, online computer databases, and videotapes, publisher's catalogs, and sources of information on courses.

Users should note that each book or other item cited here has been assigned a number. These numbers are used by the extensive index, which includes authors, titles, and organization names. The index appears following the last section of the bibliography.

Users who wish to go beyond the immediate scope of this curriculum, and discover other library and information sources helpful in solving industrial engineering problems will find guidance in two sections of the bibliography, "Miscellaneous Research Sources," and "Finding Information Online." Our goal here has been not merely to list the most useful sources, but also to provide the student with methods for finding additional sources, and newer sources as they become available. It is our hope that this document will remain useful over a number of Years.

Suggested Minimum Library

If your shipyard owns none of the books listed here, we recommend that you invest in the following toolkit of problem-solving references. Full information on these books can be found in the bibliography at the entry numbers shown.

015. Salvendy. HANDBOOK OF INDUSTRIAL ENGINEERING. \$79.95

021. SNAME Panel SP-9. NATIONAL SHIPBUILDING RESEARCH PROGRAM MICROFICHE LIBRARY ABSTRACT REPORT.

220. Rowntree. STATISTICS WITHOUT TEARS. \$6.95

275. Hillman. THE ART OF WRITING BUSINESS REPORTS. \$12.95

290. Smith. MAKING SUCCESSFUL PRESENTATIONS. \$12.95

342. Baumeister. MARKS' STANDARD HANDBOOK FOR MECHANICAL ENGINEERS. \$69.50

Total investment (at 1985 list prices): \$182.30

Introductory & General Sources on Industrial Engineering

- 005 Maynard, H. B. INDUSTRIAL ENGINEERING HANDBOOK, 3rd edition. (1971: published by McGraw-Hill, Hightstown, NJ 08520; ISBN 0-070-41084-~ \$79.95.) This is a thorough guide to concepts and methods of IE. Section I, "The Industrial Engineering Function," pp. 1.3-1.69, is a useful introductory text.
- 010 METHODS ENGINEERING WORKSHOP FOR THE SHIPBUILDING INDUSTRY, COURSE MANUAL. (being revised; from: SNAME/MARAD Program Office, Bath Iron Works, 700 Washington St., Bath, ME 04530.) Designed to provide the course materials for up-to-date training in techniques and application of methods engineering, plus detailed case studies of methods engineering applications in shipyards.
- 015 Salvendy, Gavriel. HANDBOOK OF INDUSTRIAL ENGINEERING. (1982: published by John Wiley & Sons, 605 Third Ave., New York, NY 10158; ISBN 0-471-05841-6; \$79.95.) Similar to Maynard, but newer. Like the Maynard book, it includes a useful introductory section titled "Industrial Engineering Function," pp. 1.1.1-1.6.13. This handbook also includes many very recent references to books and articles.
- 020 Hicks, Philip E. INTRODUCTION TO INDUSTRIAL ENGINEERING AND MANAGEMENT SCIENCE. (1977: published by McGraw-Hill, Hightstown, NJ 08520; ISBN 0-070-28767-8; \$29.50.) A modern textbook which gives a concise introduction to the basic concepts of industrial engineering, including methods engineering, facilities planning and design, human engineering, production control, inventory control, and cost control. A good list of references appears at the end of each chapter.
- 021 Society of Naval Architects and Marine Engineers. Panel SP-9 on Education. NATIONAL SHIPBUILDING RESEARCH PROGRAM MICROFICHE LIBRARY ABSTRACT REPORT. (1984: from NSRP Publications Coordinator, Transportation Research Institute, University of Michigan, 2901 Baxter Road, Ann Arbor, MI 48109.) This 63-page listing and description of technical reports is an essential reference. Of particular interest: reports from SNAME Panel SP-8, on Industrial Engineering. This includes reports of IE work from several shipyards; several reports deal with the MOST system (Maynard Operations Sequence Technique). All reports available on microfiche from the source above.

Work Measurement

The first three textbooks listed below are in general use in the United States. Listed after these texts are other books that may be useful to shipyard personnel responsible for industrial engineering practices.

- 025 Barnes, Ralph M. MOTION & TIME STUDY: DESIGN AND MEASUREMENT OF WORK, 7th edition. (1980: published by John Wiley, 605 Third Ave., New York, NY 10158; ISBN 0-471-05905-6; \$37.95).
- 030 Mundel, Marvin E. MOTION & TIME STUDY, 5th edition. (1978: published by Prentice-Hall, Box 500, Englewood Cliffs, NJ 07632; ISBN 0-136-02987-6 \$31.95).
- 035 Niebel, Benjamin W. MOTION & TIME STUDY, 7th edition. (1982: published by Richard D. Irwin, 1818 Ridge Road, Homewood, IL 60430; ISBN 0-256-02527-4, \$27.95).
- 036 Oakes, William S. DEVELOPING WORK STANDARDS (1985: Industrial Engineering and Management Press, Institute of Industrial Engineers, 25 Technology Park/Atlanta, Norcross, GA 30092; ISBN 0-898-06072-9; \$37.50). A selection of brief, idea-packed journal articles and conference papers, includes contributions by professionals in shipbuilding.

- 040 International Labour Office. **INTRODUCTION TO WORK STUDY**, 3rd (revised) edition (1981: published by ILO Publications, International Labour Office, Washington Branch, 1750 New York Ave. N.W., Suite 311, Washington, DC 20006; ISBN 9-221-01939-X; \$14.25). Clear, simple, and thorough text used in management training in many nations, including Japan. Includes a generous number of examples.
- 045 Larkin, J. A. **WORK STUDY**. (1969: published by McGraw- Hill; out of print; OCLC #17927). Of particular interest: Chapters 4 & 5, "Method Study, Parts 1 & 2," pp. 25-88, and Chapter 8, "Work Measurement," pp. 99-139. Written from a British standpoint, but makes a very clear presentation of important ideas in industrial engineering.
- 050 Maynard, **INDUSTRIAL ENGINEERING HANDBOOK**. Of particular interest: Section 3, "Work measurement techniques," pp. 3.3- 3.189; Section 4, "Applied work measurement," pp. 4.3-4.104. (See no. 005 for full information)
- 055 Salvendy, Gavriel. **HANDBOOK OF INDUSTRIAL ENGINEERING**. Sections of particular interest: Section 4, "Performance measurement and control of operation," pp. 4.1.1-4.9.32. Based on more recent references than the similar section in Maynard's book. (See no. 015 for full info.)
- 060 Zeyher, Lewis R. **PRODUCTION MANAGER'S HANDBOOK OF FORMULAS AND TABLES**. (1972: published by Prentice-Hall, Englewood Cliffs, NJ; out of print; OCLC #257472.) Useful as a quick reference and refresher for the individual who is already acquainted with information-gathering methods used in the shop. Of particular interest chapter 2, "Work Measurement: Time Study Standards and Work Sampling," pp. 31-53.

Additional References Useful in Work Measurement:

- 065 Berdie, Douglas R. **QUESTIONNAIRES: DESIGN AND USE**. (1974: Scarecrow Press, 52 Liberty St., Box 656, Metuchen, NJ 08840; ISBN 0-81 0-80719-X; \$13.) Useful for anyone using questionnaires, although the orientation of the book is tilted toward social science users. Includes an extensive survey and analysis of the literature.
- 070 Dunns, Cal W. **PROFESSIONAL INTERVIEWING**. (1980: published by Harper & Row, 10 E 53rd St, New York NY 10022; \$12.95; ISBN 0-060-41736-6). Covers the basic processes of interviewing, including common problems associated with asking questions, structuring the interview, establishing a productive climate, and listening analytically. Chapter 20 gives special attention to "Organizational diagnosis: the internal survey."

Predetermined Time Standards

- 075 Maynard, H. B. **INDUSTRIAL ENGINEERING HANDBOOK**. See section 5, "Predetermined time standards," pp. 5.3-5.121. (For full info, see no. 005.)
- 080 Machinability Data Center. **MACHINING DATA HANDBOOK**, 3rd ed. (1980: published by Metcut Research Associates, 3980 Rosslyn Drive, Cincinnati OH 45209; \$150.; ISBN 0-936-97400-1). "Standard reference for making machining decisions." Includes speeds and feeds for most materials on all common machine shop tools. Data permits calculation of machining time.
- 085 Ostwald, Phillip F. **AMERICAN MACHINIST MANUFACTURING COST ESTIMATING GUIDE**. (1983: published by McGraw-Hill, 1221 Avenue of the Americas, New York, NY 10020; ISBN 0-076-06831-5; \$90.00) Includes "comprehensive data tables which show the time involved and cost data for materials, labor, and machine usage..." Includes new processes and technologies.
- 086 Society of Naval Architects and Marine Engineers. Panel SP-9 on Education. **NATIONAL SHIP-BUILDING RESEARCH PROGRAM MICROFICHE LIBRARY ABSTRACT REPORT**. (See no. 021 for full info.) This is an essential reference, listing many reports that deal with predetermined time standards and the MOST system (Maynard Operation Sequence Technique). All reports available on microfiche from the source above.

- 087 Taylor, Theodore, HANDBOOK OF ELECTRONICS INDUSTRY COST ESTIMATING DATA (1985: published by Wiley-Interscience, 605 Third Ave., New York, NY 10158; ISBN 0-471-82264-7; \$59.50). Based on ELECTRONICS INDUSTRY COST ESTIMATING DATA, by Fred C. Hartmeyer (1964). The only text of its type. Includes estimating standards for electronic work, including metalworking, electroplating, and printed circuit board fabrication. With contributions by Robert K. Jenner and James A. Burbank II.
- 090 Tucker, Spencer A. THE COMPLETE MACHINE-HOUR IUTE SYSTEM FOR COST-ESTIMATING AND PRICING. (1975: published by Prentice-Hall, Box 500, Englewood Cliffs, NJ 07632 ISBN 0-131-60721-9; \$49.95.) The standard reference on the machine-hour rate system: "a company that uses production facilities.. should look at itself as being in the business of selling the time of its facilities." In this book Tucker develops the concept with worked-out examples; included are many useful forms.
- 091 U. S. Dept. of Defense. Office of the Assistant Secretary (Installation & Logistics). VALUE ENGINEERING. DOD 5010.8-H. (1981: for sale by U. S. Government Printing Office, Washington, DC 20402; see entry #100 for full order information. Stock no. S/N 008-007-01068-9; \$5.00.)
- 092 U. S. Dept. of Defense. WORK MEASUREMENT. MIL-STD- 1567A. (For sale by Techinfo Dept., National Standards Association, 5161 River Road, Bethesda, MD 20816; NSA Card No. 129; \$5.00.)
- 095 Zeyher, Lewis R. PRODUCTION MANAGER'S HANDBOOK OF FORMULAS AND TABLES. Useful as a quick reference and refresher for the individual who is already acquainted with information-gathering methods used in the shop. See chapter 3, "Work Measurement: Predetermined Time Standards: Methods-Time Measurement and Work Factor System," pp. 55-80. (For full info, see no. 060.)
- 100 In addition to the sources listed above, the following U. S. Department of Defense series of publications on "engineered performance standards" is particularly significant to shipyards. Publications in this series can be ordered from the Superintendent of Documents, U. S. Government Printing Office, Washington, DC 2040Z prepayment is required (phone orders to the GPO at 202/783-3238 may bill to a VISA/Mastercard account).
- 105 ENGINEERED PERFORMANCE STANDARDS:
- 110 Carpentry handbook. NAVFAC P-702.O (Stock No. 008-050-430218-2; \$10.)
- 115 Electric, electronic handbook. NAVFAC P-703.O (Stock No. 008-050-002174, \$7.50)
- 120 Emergency/service handbook. NAVFAC P-705.O (Stock No. 008-040-00086-9; \$5.)
- 125 Heating, cooling, and ventilation handbook. NAVFAC P- 704.0 (Stock No. 008-050-00216-6; \$6.50)
- 130 Janitorial handbook. (Out-of-print; in many libraries as Supt. of Documents No. D167 J25.)
- 135 Machine shop, machine repairs handbook. NAVFAC P-707.O (Stock No. 008-050-00227-1; \$6.)
- 140 Masonry handbook. NAVDOCKS P-708.O (Stock No. 008-050- 00146-1; \$7.)
- 145 Moving, rigging handbook. (Out-of-print; in many libraries as Supt. of Documents No. D167 M86.)
- 150 Paint handbook. NAVFAC P-710.O (Stock No. 008-050- 00172-1; \$5.50)
- 155 Pipefitting, plumbing handbook. NAVFAC P-711.O (Stock No. 008-050-00228-0; \$7.)
- 160 Preventive/recurring maintenance handbook. NAVFAC P-717.O (Stock No. 008-050-00215-8; \$5.)
- 165 Roads, grounds, pest control & refuse collection handbook. NAVFAC P-712.O. (Stock No. 008-050-00147-0; \$6.50)

- 170 Sheet metal, structural iron & welding handbook. NAVFAC P-713.O (Stock No. 008-050-00231-0; \$6.)
- 175 Unit price standards handbook. NAVFAC P-716.O (Stock No. 008-047-00221-1; \$11.)
- 180 Wharfbuilding handbook. NAVFAC P-715.O (Stock No. 008- 050-00187-9; \$5.50.)

Math, Algebra, and Statistics for Industrial Engineering

Many larger bookstores, especially chain stores and college stores, have a wide selection of text /workbooks in math for the reader who wants to teach himself. Three different publishers have put out inexpensive self-teaching texts often found in such stores.

Doubleday, 501 Franklin Ave., Garden City, NY 11530, produces the "Made Simple" books, which include:

- 185 MATHEMATICS by Abraham Sperling and Monroe Stuart (ISBN 0-385-17481-0; \$4.95)
- 190 INTERMEDIATE ALGEBRA AND ANALYTIC GEOMETRY by William K. Gondin and and Bernard Sohmer (0-385-00437-0; \$4.95)
- 195 STATISTICS by H. T. Hayslett (0-385-02355-3; \$4.95).
- ARCO (215 Park Avenue South, New York, NY 10003) known for its exam preparation books, publishes:
- 200 ALGEBRA SIMPLIFIED AND SELF-TAUGHT, by David Frieder (ISBN 0-668-05797-1; \$5.95)
- 205 STATISTICS SIMPLIFIED AND SELF-TAUGHT, by Stanley H. Stearn (ISBN 0-668-05813-7; \$6.95).
- Barron's (113 Crossways Park Drive, Woodbury NY 11797) known for its school and college guidebooks, produces the "Easy Way" series, which includes, among other titles:
- 210 STATISTICS, by D. Downing and J. Clark (ISBN 0-812- 02666-7; \$6.95).
- 215 Sometimes found with the first three series are the "Schaum Outlines" published by McGraw-Hill. While useful to the person who is taking or has already taken a classroom course in the subject, the "Schaum outlines" are less useful to the novice than the first three series mentioned.
- 220 Rowntree, Derek. STATISTICS WITHOUT TEARS: A PRIMER FOR NON-MATHEMATICIANS. (1981: published by Scribners, Order Dept., Front & Brown Sts., Riverside, NJ 08075; ISBN 0-684-17502-9; \$6.95) Written for the person who has a practical need to put statistical tests to work, but who has little background in mathematics. The author leads the reader into an understanding of basic statistical concepts through words and pictures. He also puts questions to the reader at strategic points (and later answers them) in order to make the reader grasp the necessary ideas.
- 225 Huff, Darrell & Geis, Irving. HOW TO LIE WITH STATISTICS. (Published by W. W. Norton, 500 Fifth Ave., New York, NY 10110; ISBN 0-393-09426-X; \$1.95.) This book has more going for it than a catchy title. The authors don't intend to teach you how to deceive.. but rather how to see through statistics, and ask the right statistical questions. This is a classic.
- 230 Sharp, Vicki F. HOW TO SOLVE STATISTICAL PROBLEMS WITH YOUR POCKET CALCULATOR. (1982: published by TAB Books, Blue Ridge Summit, PA; O-830-61303-X; \$8.95.) Not a basic text, but a useful handbook for people who are familiar with elementary statistical applications.
- 235 Williams, William Howard. A SAMPLER ON SAMPLING. (1978: published by John Wiley & Sons, 605 Third Ave., New York, NY 10158; \$29.95.) 254p. Leads the reader through the mechanics and considerations involved. A step-by-step approach leads to final chapters on designing one's own survey, and criticizing another's.

- 240 Spence, William P. ENGINEERING GRAPHICS. (1984: published by Prentice-Hall, Box 500, Englewood Cliffs, NJ 07632; ISBN 0-132-78879-9; \$29.95.) 770p. Modern textbook includes descriptive geometry, vector analysis, graphical analysis, and computers in graphics.

Electronic Assistance

- 245 Krouse, John K. WHAT EVERY ENGINEER SHOULD KNOW ABOUT COMPUTER-AIDED DESIGN AND COMPUTER-AIDED MANUFACTURING: THE CAD/CAM REVOLUTION. (1982: published by Synapse Books, 912 Cherry Lane, Vestal, NY 13850; ISBN 0-824-71666-3; \$22.50) "Provides the big picture on CAD/CAM... highlights practical engineering examples demonstrating the day-to-day utility of CAD/CAM."
- 250 Teicholz, Eric. CAD/CAM HANDBOOK. (1985: published by McGraw-Hill, Hightstown, NJ 05820; 0-070-63403-3; \$49.95.) Overview and introduction to state of the art CAD/CAM. Discusses types of systems, criteria for acquisition, and looks at applications in engineering and in process planning.

Financial Analysis

- 255 Carson, Gordon B. PRODUCTION HANDBOOK, 3rd edition. (1972: published by Ronald Press, distributed by John Wiley & Sons, 605 Third Avenue, New York, NY 10158; ISBN 0-472-06651-6; \$74.95.) Of particular interest: section 4, "Materials management," which covers order & requisition systems; chapter 5, "Inventory control," which covers make-or-buy decisions, and economic order quantities.
- 260 Magee, John F., and Boedman, David M. PRODUCTION PLANNING AND INVENTORY CONTROL, 2nd edition. (1982: published by McGraw-Hill, Hightstown, NJ 08520; ISBN 0-070-39488-1; \$36.95.) In short: how to manage inventories economically. Of particular interest: chapter 3, "Cost factors in production and inventory control," pp. 30-52, and chapter 4, "Economic quantities of manufacture or purchase," pp. 53-80.
- 265 Shupe, D. S. WHAT EVERY ENGINEER SHOULD KNOW ABOUT ECONOMIC DECISION ANALYSIS. (1980: published by Synapse Books, 912 Cherry Lane, Vestal, New York 13850; ISBN 0-824-7019-3; \$19.75.)
- 270 Zeyher, Lewis R. PRODUCTION MANAGER'S HANDBOOK OF FORMULAS AND TABLES. Of particular interest: appendix A, "Make or Buy," pp. 223-244. Very useful once you are acquainted with the basic principles of financial analysis. (See no. 060 for full info.)
- 271 Pyle, William W. & Larson, Kermit D. FUNDAMENTAL ACCOUNTING PRINCIPLES, 9th edition. (1981: Richard D. Irwin, 1818 Ridge Road, Homewood, IL 60430; ISBN 0-256-02386-7; \$28.95.) An introductory accounting text with good definitions of terms. A programmed learning aid is available to complement the text.

Data Presentation

- 275 Hillman, Howard. ART OF WRITING BUSINESS REPORTS AND PROPOSALS. (1981: published by Vanguard Press, 425 Madison Ave., New York, NY 10017; ISBN 0-814-90850-0; \$12.95.) Hillman leads the first-time report writer from the pre-writing stage, through drafts and reorganization, to the finished report. Includes a good example of a clear, concise business report.
- 280 Filley, Richard D. & Szoka, Kathryn. COMMUNICATING WITH GRAPHICS: a reprint of a series from Industrial Engineering. (1982: published by Industrial Engineering Publications Sales, Institute of Industrial Engineers, 25 Technology Park/Atlanta, Norcross GA 30092, phone 404/449-0460; ISBN 0-898-06036-2). How to choose the right type of chart? How to make a chart or graph that's professional in appearance? The answers are in this booklet, which reprints articles from the IIE magazine.

- 285 Kemp, Jerrold E. **PLANNING & PRODUCING AUDIOVISUAL MATERIALS**, 4th edition. (1980: published by Crowell, distributed by Harper& Row, 10 East 53rd Street, New York, NY 10022; ISBN 0-060-43587-9; \$32.50.) This standard guide teaches the essentials: thinking about and planning the message to be presented; basic skills in 35mm photography, graphics, and sound recording; producing slides, photos, graphs, overheads, sound, and video. Includes useful supplier addresses.
- 290 Smith, Terry C. **MAKING SUCCESSFUL PRESENTATIONS: A SELF-TEACHING GUIDE**. (1984: published by John Wiley & Sons, 605 Third Ave., New York, NY 10158; ISBN 0-471-88777-3; \$12.95.) Smith covers the presentation process, from organizing to visual aids to fielding questions and dealing with a hostile audience.
- 295 Strunk, William, Jr. & White, E. B. **THE ELEMENTS OF STYLE**, 3rd edition. (1979: published by Macmillan, Front & Brown Sts., Riverside, NJ 08370; ISBN 0-024-18190-0; stocked in most bookstores.) This is an absolutely basic reference for anyone who writes, and wants to write better.
- 300 Trelease, Sam. **HOW TO WRITE SCIENTIFIC AND TECHNICAL PAPERS**. (1969; published by MIT Press, 28 Carleton St., Cambridge, MA 02142; ISBN 0-262-70004-2; \$5.95). Easy-to-follow directions on report writing.

Equipment & Facilities

- 305 Apple, J. M. **PLANT LAYOUT AND MATERIALS HANDLING**, 3rd edition. (1977: published by John Wiley, 605 Third Ave., New York, NY 10158; ISBN 0-471-06652-4; \$35.50.) A modern text.
- 310 Kantowitz, Barry H. **HUMAN FACTORS: UNDERSTANDING PEOPLE-SYSTEM RELATIONSHIPS**. (1983: published by John Wiley & Sons, 605 Third Ave., New York, NY 10158; ISBN 0-471-09594-X; \$ 36.95.) Modern text introduces all aspects, including human-machine relationships; extensive bibliography.
- 315 Illuminating Engineering Society. **IES LIGHTING HANDBOOKS: REFERENCE AND APPLICATIONS VOLUMES**, 6th edition. (1981: published by Illuminating Engineering Society of North America, 345 E 47th St., New York, NY 10017; ISBN 0-686-47912-2; \$107.) Includes standard formulas, theory and practice of lighting; prescribes levels of illumination.
- 320 Maynard, H. B. **HANDBOOK OF INDUSTRIAL ENGINEERING**. Section 11, "Equipment and facilities," which includes chapters on plant layout, equipment selection. (For full info, see no. 005.)
- 325 Moore, James M. **PLANT LAYOUT & DESIGN**. (1962: Macmillan, Front & Brown Sts., Riverside, NJ 08370; ISBN 0-023-83180-4; \$28.95.)
- 330 Muther, Richard. **PRACTICAL PLANT LAYOUT**. (1956: McGraw-Hill, Hightstown, NJ 08520; ISBN 0-070-44156-1; \$36.95.)
- 335 Salvendy, Gavriel. **HANDBOOK OF INDUSTRIAL ENGINEERING**. Pertinent to this topic: section 10, "Facilities design," which includes chapters on plant & office layout. (For full info, see no. 015.)
- 340 Woodson, Wesley E. **HUMAN FACTORS DESIGN HANDBOOK**. (1981; published by McGraw-Hill, Hightstown, NJ 08520; ISBN 0-070-71765-6; \$89.50.)
- 341 Moffat, Donald W. **PLANT ENGINEER'S HANDBOOK OF FORMULAS, CHARTS, AND TABLES**, 2nd edition. (1982: Prentice Hall, Box 500, Englewood Cliffs, NJ 07632; ISBN 0-136-80298-2; \$57.95.)
- 342 Baumeister, Theodore. **MARKS' STANDARD HANDBOOK FOR MECHANICAL ENGINEERS**, 8th edition. (1978: McGraw-Hill, Hightstown, NJ 08520; ISBN 00070-04123-7; \$69.50.)

Purchasing, Warehousing, Material Handling

- 345 Carson, Gordon B. PRODUCTION HANDBOOK. Of particular interest: section 17, "Material handling." (For full info, see no. 255.)
- 350 Leenders, Michael R. PURCHASING AND MATERIALS MANAGEMENT, 7th edition. (1980: published by Richard D. Irwin, 1878 Ridge Road, Homewood, IL 60430; ISBN 0-256-02374-3; \$30.95.)
- 355 Maynard, H. B. INDUSTRIAL ENGINEERING HANDBOOK. Of particular interest: section 11, "Equipment and facilities," which includes a chapter on materials handling. (For full info, see no. 005.)
- 360 Salvendy, Gavriel. HANDBOOK OF INDUSTRIAL ENGINEERING. See section 10, "Facilities design," which includes chapters on materials handling systems, and storage and warehousing. (For full info, see no. 015.)
- 365 Zeyher, Lewis R. PRODUCTION MANAGER'S HANDBOOK OF FORMULAS AND TABLES. Of particular interest: chapter 5, "Materials handling formulas," chapter 6, "Warehousing formulas," and Appendix B, "Warehousing." Useful as a review or refresher for people who are learning the basic principles. (For full info, see no. 060.)

Safety

- 370 Boley, Jack W. A GUIDE TO EFFECTIVE INDUSTRIAL SAFETY. (1977: Gulf Publishing Co., P. O. Box 2608, Houston, TX 77001; ISBN 0-872-01798-2; \$12.95) Covers the essentials of safety in industry, including safety assessment and analysis. Includes a good guide to the literature.
- 375 OSHA: the U. S. Occupational Health and Safety Administration produces a number of useful and essential publications of interest to shipyards. For a complete listing of available OSHA publications, write or phone the OSHA Publications Distribution Office, Occupational Safety and Health Administration, Department of Labor, 200 Constitution Ave., N. W., Room S1212, Washington DC 20210; 202-523-6138. Of special interest:
- 380 SHIPYARD INDUSTRY OSHA SAFETY AND HEALTH STANDARDS (OSHA publication no. 2268). Pocket-size booklet deals with job safety and health rules and regulations issued by OSHA for shipyards. Includes the relevant sections of the Code of Federal Regulations (CFR).
- 385 GENERAL INDUSTRY: OSHA SAFETY AND HEALTH STANDARDS (OSHA publication no. 2206). Includes the general provisions, as officially stated in the Code of Federal Regulations (CFR).
- 390 NIOSH (National Institute for Occupational Safety and Health), also produces useful publications. For their catalog, write to: Clearinghouse for Occupational Safety and Health Information, NIOSH, Center for Disease Control, 4676 Columbia Parkway, Cincinnati, OH 45226.

Quality

- 394 Case, Kenneth. PROFIT THROUGH QUALITY: QUALITY ASSURANCE PROGRAMS FOR MANUFACTURERS. (1978: published by Publications Office, Institute of Industrial Engineers, 25 Technology Park/Atlanta, Norcross, GA 30092; 0-898-06005-2; \$15.00.) Text oriented to the real world.
- 395 Juran, Joseph M. QUALITY CONTROL HANDBOOK. (1974 published by McGraw-Hill, Hightstown, NJ 08520; ISBN 0-070-33175-8; \$64.95.) Massive, comprehensive text attacks many aspects of the quality control problem. Includes specific chapters on metals, metal fabrication, mechanical components, and assembly operations.

Planning, Scheduling, and Production Control

- 400 Magee, John F., and Boodman, David M. PRODUCTION PLANNING AND INVENTORY CONTROL, 2nd edition. Magee & Boodman also cover the basics of inventory systems, production planning, and scheduling. (For full info, see no. 260.)
- 405 Maynard, H. B. INDUSTRIAL ENGINEERING HANDBOOK. Of particular interest: section 8, "Planning and control procedures," which includes systems analysis, operations planning, scheduling, and control, and inventory management and control. (For full info, see no. 005.)
- 410 Salvendy, Gabriel. HANDBOOK OF INDUSTRIAL ENGINEERING. Of particular interest: Section 11, "Planning and control." (For full info, see no. 015.)
- 415 Wilson, Frank C. PRODUCTION PLANNING & CONTROL HANDBOOK. (1980: published by Prentice-Hall, Box 500, Englewood Cliffs, NJ 0-137-25192-0; \$55.00.) A modern textbook.
- 420 Zeyher, Lewis R. PRODUCTION MANAGER'S HANDBOOK OF FORMULAS AND TABLES. See chapter 1, "Production Control and Inventory Turnover," pp. 25-30. (For full info, see no. 060.)

Networking

- 425 Carson, Gordon B. PRODUCTION HANDBOOK, 3rd edition. Of particular interest: section 10, "Operations research," which discusses the PERT and CPM networking techniques. (For full info, see no. 255.)
- 430 Lang, Douglas W. CRITICAL PATH MANAGEMENT, 2nd edition. (1977: part of the McKay "Teach Yourself" series, published by Fodor's-McKay, O'Neill Hwy., Dunmore, PA 18512; ISBN 0-679-10504-2; \$6.95.) Concise, well-written, step-by-step approach, with many examples and case studies.
- 435 Moder, Joseph J. & Phillips, Cecil R. PROJECT MANAGEMENT WITH CPM AND PERT, 2nd edition. (1970: Van Nostrand Reinhold; out-of-print, but a third edition has been announced by the publisher.) Moder & Phillips cover the basics of the network plan concept, using the Critical Path Method (CPM) and the Program Evaluation and Review Technique (PERT). The reader is led through the steps, from sketching out the network to making time estimates and computing schedules. Topics are very clearly presented, with many down-to-earth, practical examples.
- 440 Ruskin, A. M. & Estes, W. U. WHAT EVERY ENGINEER SHOULD KNOW ABOUT PROJECT MANAGEMENT. (1982: published by Synapse Books, 912 Cherry Lane, Vestal, New York 13850.)

Support Services

- 445 Akers, Herbert. MODERN MAILROOM MANAGEMENT. (1979: published by McGraw-Hill, Hightstown, NJ 08520; ISBN 0-070-00760-8; \$24.95.)
- 450 Rakes, Gar, editor. FORMS FOR THE '80s: HOW TO DESIGN AND PRODUCE THEM. (1981: published by North American Publishing Co., 401 N. Broad St., Philadelphia, PA 19108; ISBN 0-912-92054-8; \$29.50). A down-to-earth guide written by a group of business-forms professionals. Suggests ways to think through forms design for improved efficiency. Gives attention to forms-production equipment common in the 1980's.
- 455 Osteen, Carl E. FORMS ANALYSIS: A MANAGEMENT TOOL FOR DESIGN AND CONTROL. (1969: published by Office Publications, Inc., Stamford, CT; ISBN 0-911 -05407-4 \$10.75.) Somewhat dated, but still useful for its discussion of organization, layout, and design of forms.

Miscellaneous Research Sources Including Bibliographies, Handbooks, Indexes, and Journals.

Here are some basic reference tools useful in the practice of industrial engineering. These sources are not listed in other modules of this bibliography. Many of these books are worth purchasing for use in the office; others may be used only infrequently, and can often be found in libraries.

- 460 Aluri, Rae, and Robinson, Judith Schiek. **A GUIDE TO U.S. GOVERNMENT SCIENTIFIC AND TECHNICAL RESOURCES**. (1983: published by Libraries Unlimited, Inc., P.O. Box 263, Littleton, CO 80160-0263; ISBN 0-872-87377-3; \$23.50; available in many libraries). Focuses on technical sources, unlike most other guides to federal information.
- 465 American National Standards Institute. **CATALOGUE OF AMERICAN NATIONAL STANDARDS**. (Write for current information: American National Standards Institute, 1430 Broadway, New York NY 10018; phone 212/354-3311.) See also no. 810.
- 470 **APPLIED SCIENCE AND TECHNOLOGY INDEX**. (subscription from H. W. Wilson Co., 950 University Avenue, Bronx, NY 10452; in most larger libraries.) Easy-to-use index to over 200 periodical publications including automation, engineering, metallurgy, transportation, and many other fields. Also searchable online (See no. 770.)
- 480 **BUILDING CONSTRUCTION COST DATA**. (Annual, from: National Association of Home Builders, 15th & M Street N.W., Washington, DC 20005; the 1984 edition was \$32.25.) Average costs for labor and material, organized by item, e.g. brick, concrete.
- 485 Chen, Ching-Chi. **SCIENTIFIC AND TECHNICAL INFORMATION SOURCES**. (1977: published by MIT Press, 28 Carleton St., Cambridge, MA 02139; ISBN 0-262-03062+ \$47.50.) Good source listing of the basic sources in many aspects of manufacturing and engineering.
- 490 **DODGE BUILDING COST SERVICES**. (Continuous updating; subscriptions from: F. W. Dodge Division, McGraw-Hill, 1221 Avenue of the Americas, New York, NY 10020.) Expensive professional publication sometimes found in company libraries and university business libraries.
- 495 **ENCYCLOPEDIA OF ASSOCIATIONS**. (Frequently revised; published by Gale Research Co., Book Tower, Detroit, MI; available in most libraries.) Very useful guide to all national trade, engineering, and other professional organizations in the U.S.
- 500 **ENGINEERING INDEX**. (subscription from: Engineering Information Inc., 345 E. 47th St., New York, NY 10017; Usually available at the libraries of universities which offer engineering courses.) The standard index to periodicals in engineering. Also available as an online database, COMPENDEX. (See no. 775.)
- 505 Fink, Donald, **STANDARD HANDBOOK FOR ELECTRICAL ENGINEERS**. 11th Edition. (1978: from McGraw-Hill; ISBN 0-070-20981-2; \$74.95.) The basic source in electric engineering.
- 510 **INDUSTRIAL ENGINEERING INDICES**. Annual index to the journal of the IIE, **INDUSTRIAL**
515 **ENGINEERING**. Provides a ready listing, by subject, to recent articles. (Information from: Publications Order Dept., Institute of Industrial Engineers, 25 Technology Park, Norcross, GA 30092.)
- 520 **JOURNAL OF SHIP PRODUCTIONS**. (quarterly, from: Society of Naval Architects and Marine Engineers. 1 World Trade Center 1369, New York, NY 10048; annual subscription \$17 to members, \$40 to non-members.) Launched in February 1985, this is a "new technical journal, to publish papers concerned with the problems of shipyard techniques and production of naval and merchant ships."
- 525 Lesko, Matthew. **INFORMATION U. S. A.** (1983: published by Viking Penquin, 40 West 23rd, New York, NY 10010; ISBN 0-140-46564-2; \$19.95 for paperback; also available in \$50 hardcover edition.) A well-organized, easy-to-use guide to federal government information sources.
- 530 **MCGRAW-HILL DICTIONARY OF SCIENTIFIC AND TECHNICAL TERMS**, 3rd edition. (1983: McGraw-Hill, Hightstown, NJ 08520; ISBN 0-070-45269-5; \$70.00.)

- 535 MCGRAW-HILL ENCYCLOPEDIA OF SCIENCE AND TECHNOLOGY, 5th ed. 15 vols. (1982: from McGraw-Hill, as above ISBN 0-070-79280-1; \$935; in most libraries.) The standard technical encyclopedia; many articles on materials, chemical and physical principles, manufacturing and engineering processes. This is the place to look for a concise, authoritative summary on an engineering topic. Most articles include a short list of the most important books and references for the topic. More
- 540 affordable and narrowly-focused spinoff volumes from this work include: MCGRAW-HILL ENCY-
- 545 CLOPEDIA OF ENERGY. (1980: ISBN 0-070-45268-7; \$49.50) and MCGRAW-HILL ENCYCLOPEDIA OF ENGINEERING. (1983: ISBN 0-070-45486-8; \$57.50.)
- 550 METALS HANDBOOK. (published by: American Society for Metals, 9639 Kinsman Road, Metals Park, OH 44073: write for current information.) Ten volumes on various topics, revised regularly and sold individually; about \$80 per volume in 1985. Covers all aspects of metal working. Forming, welding and failure analysis volumes are especially good. See also METALS DATA FILE in the online database listing (no. 795.)
- 555 Oberg, Erik. MACHINERY'S HANDBOOK. (Frequent revisions 1984 edition from. Industrial Press Inc., P. O. Box C-772, Brooklyn, NY 11205; ISBN 0-831-11155-0; \$45.; also available, for use with
- 560 MACHINERY'S HANDBOOK, is a GUIDE TO FORMULAS AND TABLES, ISBN 0-831-11156-9, \$9.95.) Reference for machine shop and mechanical engineer.
- 565 (See entry nos. 21, 86.)
- 570 SUBJECT GUIDE TO BOOKS IN PRINT. (Annual, from : R. R. Bowker, 205 E. 42nd St., New York, NY 10017; available for use in nearly all libraries and bookstores.) Standard tool for finding out what's available from U. S. publishers. Uses the same system of subjects as most libraries. (See "Standard Terms for Use in Library Searches," at the end of this listing.)
- 575 U. S. General Services Administration. INDEX OF FEDERAL SPECIFICATIONS, STANDARDS, AND COMMERCIAL ITEM DESCRIPTIONS. (Order from: U. S. Government Printing Office, Washington, DC 20402; Stock No. 022-001-81002-9; \$29 for subscription, which includes one copy of basic catalog plus updates for one year.) Monthly and cumulated annually. (See also no. 810.)
- 580 UNITED STATES GOVERNMENT MANUAL. (Annual: order from U.S. Government Printing Office, Washington, DC 20402; in most libraries.) The standard source for addresses and telephone numbers of departments, agencies, commissions, and names of current officials. See also no. 525, Lesko's INFORMATIONS USA.

STANDARD TERMS FOR USE IN LIBRARY SEARCHES

Most company, public, and university libraries in the United States utilized a system of standard subject terms in their catalogs. This is generally true of libraries with computerized catalog systems, as well as libraries that maintain card catalogs.

Searching for a subject in a library catalog, and getting results, depends on searching for the right subject terms. Listed below are the subject terms most likely to be useful in searching for industrial engineering material.

585 (Note: The system of subject terms from which this set is drawn is called the Library of Congress Subject Headings.)

590	Assembly-line methods
595	Automation
600	Break-even analysis
605	Costs, Industrial
610	Engineering economy
615	Human engineering
620	Industrial engineering
625	Industrial procurement
630	Industrial project management
635	Industrial relations
640	Industrial statistics
645	Machinery in industry
650	Make or buy decisions
655	Materials handling
660	Methods engineering
665	Methods - Time measurement
670	Motion study
675	Network analysis (Planning)
680	Operations research
685	Plant layout
690	Production control
695	Production engineering
700	Quality control
705	Replacement of industrial equipment
710	Scheduling management
715	Standardization
720	Systems engineering
725	Wages and labor productivity
730	Work measurement

FINDING INFORMATION ONLINE

735 An increasing number of scientific and technical information sources are now available online, for access from small personal and business computers.

There are two major types of online databases available today. It is important to know which type of system you are paying to search, and to search it efficiently. Some database services have online connect charges of \$200 per hour and up.

The most common type of commercial online databases is a massive, computerized bibliography which can be searched by entering keywords via a special command language which mayor may not be easily learned. This type of database does not provide the information directly, but rather a customized list of books and other references that are pertinent to the keywords searched. Once the list of references has been created, the searcher must then travel to the library and probably seek items through interlibrary loan, or alternatively use an online document delivery service which can be very fast and also very expensive.

The second type of database provides direct information. It is like searching the indexes to a collection of books whose contents can be displayed on the computer screen. This type of database is, of course, more immediately useful. While this type of database is rapidly proliferating, it is still less common than the bibliographic reference databases.

Performing a rewarding search of online computer databases has until very recently required some degree of training in the appropriate search languages. Such skills can often be tapped from the professional staff of a company, university, or larger public library, or sometimes from a local computer user organization. Local organizations of individuals owning business-oriented computers (IBM, CP/M) are likely to harbor people who are experienced in searching online technical, business, and engineering databases.

The need for skill in searching databases remains, but recent developments provide some encouragement for infrequent users.

740 Searching databases, including the big-league business, engineering, and technology databases, is getting easier all the time. A Pennsylvania firm, EASYNET, has recently (April 1985) introduced a simplified search service. There is no search or command language to learn. The user connects his computer and modem to the phone line, dials 1-800-EASYNET, is prompted to supply a credit card number, and then is led, step-by-step, to answer a series of questions. This approach is much more interactive, but much less powerful and sophisticated than traditional database searches, which usually consist of a series of unprompted ocmmands. The average EASYNET search probably costs \$18 to \$24. Further information from EASYNET, 134 North Narberth Avenue, Narberth, PA 19072, 1-215-664-6972.

745 Six cautions for anyone searching commercial databases for material relevant to industrial engineering:

1. Know how to use your modem. Get some practice using local computer club bulletin boards and other unknown computer systems first.
2. Know your database. Use one of the guides listed below, or some other competent source. Better yet, find someone who has experience with either the printed or the online version of the database.
3. Read one or more good references on database searching (see below).
4. Understand the concept of using Boolean logic in searching databases. This means using AND, OR, and NOT together with very specific search terms.
5. Devise a search strategy. This means knowing what kinds of material the computer is searching through, and what kinds of language will make the right items drop out. In general, use the most specific language possible. Avoid general searches. Never do a search for "Paint" for example. Always qualify the search. Ask for "PAINT and ALUMINUM and MARINE," for example, instead. (This means asking for references in which PAINT and ALUMINUM and MARINE applications are all relevant.)
6. Check out your final search strategy with someone who has experience in using (and paying for) commercial database searches before dialing up the database.

Three good references for anyone contemplating the search of online databases for industrial engineering information:

750 Edelhart, Mike, and Davies, Owen. OMNI ONLINE DATABASE DIRECTORY. (1984: Macmillan Publishing Co., 866 Third Ave., New York, NY 10022; ISBN 0-020-79910-1; \$10.95.) Nearly as useful

as the similar guides marketed to large businesses and libraries for \$200. Includes information on over 1000 databases, including many in business and industry, construction, electricity and electronics, engineering, government, metals, patents, science and technology, and government.

- 755 Glossbrenner, Alfred. COMPLETE HANDBOOK OF PERSONAL COMPUTER COMMUNICATIONS. (1984: published by St Martin's Press, 175 Fifth Ave., New York, NY 10010; ISBN 0-312-15718-5; \$14.95.) Widely hailed as the best guide to using small business computers for accessing remote databases. Includes useful information on the major database vendors. Lockheed and BRS.
- 760 Lesko, Matthew. THE COMPUTER DATA AND DATABASE SOURCE BOOK. (1984: published by Avon Books, 1790 Broadway, New York, NY 10019; ISBN 0-380-86942-X; \$14.95.) Not as complete as it claims to be, but particularly good for its listing of obscure federal government databases. Also includes many telephone contacts for getting database information verbally.

Basic Databases for Industrial Engineering

Listed here are several databases likely to be useful in researching special problems in industrial engineering. Descriptions given here are based on Edelhart's OMNI ONLINE DATABASE DIRECTORY (no. 750) and Lesko's COMPUTER DATA AND DATABASE SOURCEBOOK (no. 760). consult those volumes for more detail.

- 765 ABI/INFORM. Covers several hundred business and management periodicals. (Access via DIALOG, BRS, and others. Producer: Data Courier, 620 South Fifth, Louisville, KY 40202.)
- 770 APPLIED SCIENCE AND TECHNOLOGY INDEX. Online version of the printed index of the same name (see no. 470). (Access via and produced by: H. W. Wilson Co., 950 University Ave., Bronx, NY 10452.)
- 775 COMPENDEX. Online version of the ENGINEERING INDEX (see no. 500). Covers different types of literature (books, periodicals, reports, in the engineering disciplines. (A subset of this database is marketed at a lower rate as the ENGINEERING LITERATURE INDEX; for professional use, however, it is better to search the full version of COMPENDEX.) (Access via DIALOG, BRS, and others. Producer: Engineering Information Inc., 345 East 47th St., New York, NY 10017.)
- 777
- 780 E. H. BOECKH COMPUTERIZED BUILDING COSTS. Allows online estimating of construction costs. (Access: via General Electric Information Services. Producer: E. H. Boeckh Co., 615 East Michigan St., Milwaukee, WI.)
- 785 MARDATA (Marine Industry Data Bases). Sources of statistics on ships; based on LLOYD'S REGISTER OF SHIPPING. (Access via General Electric Information Services. Producer: Maritime Data Network, Ltd., Stamford, CT 06092, phone 800-243-7846.)
- 790 METADEX. Online bibliography on metals. Based on several printed indexes. (Access via DIALOG and others. Producer: American Society for Metals, Metals Park, OH 44073.)
- 795 METALS DATA FILE. A kind of online handbook of metals, held in high regard by its users. (Access via SDC. Producer: American Society for Metals, Metals Park, OH 44073.) (See also no. 550.)
- 800 NTIS (National Technical Information Service). Important, massive database of references to government technical reports and reports of work performed under government contract. Most items cited are not available in libraries and must be purchased from NTIS. (Access via DIALOG, BRS, and others. NTIS will also perform searches for you, for a fee. Produced by: NTIS, U. S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.) Worth writing for: NTIS publishes a free pamphlet describing its database and many other services.
- 805
- 810 STANDARDS AND SPECIFICATIONS. Permits identification and online ordering of pertinent standards & specifications documents. (Access via DIALOG. Producer: National Standards Association, Inc., 5161 River Road, Bethesda, MD 20816.) (See also nos. 465, 575.)

Addresses for Access Vendors:

The following organizations provide an interface to the databases listed above. Usually these databases can be searched only by using one of these vendors.

815 BRS (Bibliographic Retrieval Service)

Route 7
Latham, NY 12110
1-800-833-4707

820 DIALOG Information Services, Inc.

3460 Hillview Ave.
Palo Alto, CA 94304
1-800-227-1927

(Note: DIALOG is sometimes referred to as Lockheed, its parent firm.)

825 General Electric Information Services

401 N. Washington St.
Rockville, MD 20850
301/340-3536

830 SDC Information Services

2500 Colorado Ave.
Santa Monica, CA 90406
1-800-421-7229

835 Wilsonline

H. W. Wilson Co.
950 University Ave., Bronx, NY 10452
1-800-367-6770

VIDEOTAPES

Because the world of video technology is rapidly changing; because the number of educational video tapes available is explosively multiplying; and because we wish this document to retain its timeliness and usefulness over an extended period of time – we have refrained from listings individual videotapes.

Instead, we present a list of tools for finding videos which are useful now and we hope will be useful over the next several years.

- 840 VIDEO SOURCE BOOK, revised frequently. (Published by the National Video Clearinghouse, Inc., 100 Lafayette Drive, Syosset, New York 11791; ISBN 0-935478-10-8 for third edition; standard item in most libraries.) Until video tape information is widely available online, this book, found in most libraries, is the first source to consult. It includes a one-sentence description of each tape, and included information on video format, intended audience, and source of purchase and availability. Videos relevant to industrial engineering can be located by checking the “Subject Category Index” under the following categories:

- engineering
- management
- mathematics

- 845 EDUCATIONAL FILM LOCATOR, revised frequently. (Published by R. R. Bowker Co., 1180 Avenue of the Americas, New York, NY 10036; found in most libraries.) Includes information on films which have been converted to video format. Check the “Subject, Title, and Audience Level Index” in the front of the book under the following relevant headings:

- business
- engineering
- factories
- foundries
- industrial arts
- industrial management
- industrial safety
- interviewing
- job analysis
- machine shops
- manufacturing processes
- mathematics
- metallurgy
- metals
- * safety education

- 846 NICEM (National Information Center for Educational Materials) is a national clearinghouse for
847 audiovisual aids aimed at the school and college market. NICEM produces several printed indexes, including a three--volume INDEX TO EDUCATIONAL VIDEOTAPES, as well as an irregularly updated online database that can be searched via DIALOG (See no. 735). For further information, contact National Information Center for Educational Media, access Innovations, 4318 Mesa Grande Pl. SE, Albuquerque, NM 87108.

Specific Sources of Interest for Videotape Materials:

- 850 Gulf Publishing Company Video

P.O BOX 2608

Houston, TX 77001

(formerly International Training Company)

Noted for videos on safety, marine firefighting, inventory control, and management . . . write for catalog.

855 Video Loan Library

National Electrical Manufacturers Associations (NEMA)
Mr. Walter Kozikowski, NEMA Staff Executive
Automated Systems
2101 L. Street, N.W.
Washington, DC 20037

Other potential sources of videotapes which should not be overlooked include industrial engineering department in universities, vendors, and the training programs at naval shipyards.

PUBLISHER'S CATALOGS

Each of the following publishers or distributors handles a number of books which are of practical use to people engaged in industrial engineering practices. All have free catalogs on engineering and related publications which are worth obtaining.

- 860 AMERICAN TECHNICAL PUBLISHERS, 12235 South Laramie Avenue, Alsip, IL 60658. Good source of inexpensive texts covering the basic trades.
- 865 AMERICAN WELDING SOCIETY, 550 N.W. LeJeune Road, Miami, FL 33126.
- 870 CAHNERS PUBLISHING CO., P.O. Box 716, Back Bay Annex, Boston, MA 02117
- 875 INDUSTRIAL ENGINEERING AND MANAGEMENT PRESS, Institute of Industrial Engineers, Attn. Publication Sales, 25 Technology Park/Atlanta, Norcross, GA 30092. Good source of up-to-date IE references. Offers a PUBLICATIONS CATALOG and an AUDIOVISUAL RESOURCE CATALOG.
- 880 MCGRAW-HILL, Hightstown, NJ 08520. Major text and reference book publisher.
- 885 PENTON/IPC Education Division, Penton Plaza, 1111 Chester Avenue, Cleveland, OH 44114. Many down-to-earth publications for engineers and managers. Publishes the "What Every Engineer Should Know Series."
- 890 PRENTICE-HALL, Box 500, Englewood Cliffs, NJ 07632. Major text and reference book publisher.
- 895 RICHARD D. IRWIN, 1818 Ridge Road, Homewood, IL 60430. Major text and reference book publisher.
- 900 SYNAPSE BOOKS, 912 Cherry Lane, Vestal, New York 13850. Aims to "unite important publishing sources in high technology. . . each title in this catalog represents the best presently available in its subject area, theoretical viewpoint, and level of sophistication." Catalog includes books from 30 different publishers; extensive descriptions. Focus on automation, robotics, CAD/CAM/CAE.
- 905 JOHN WILEY & SONS, 605 Third Ave., New York, NY 10158. Major text and reference book publisher.

In addition to the commercial publishers listed above, there are many trade and professional associations which offer publications useful in industrial engineering. To find these associations, see no. 495.

FINDING OUT ABOUT COURSES

The following references, available in many libraries, are useful for locating colleges and technical schools which offer courses of interest to people developing skills in industrial engineering.

- 910 AMERICAN UNIVERSITIES AND COLLEGES. (Updated regularly; published by: DeGruyter, 200 Saw Mill River Road, Hawthorne, NY 10532.) Comprehensive directory compiled by the American Council on Education (ACE).
- 915 COLLEGE BLUE BOOK. Multivolume set. (Updated frequently; published by MacMillan, 866 Third
920 Ave., New York, NY 10022.) Of particular interest is the "Occupational Education" volume, which lists thousands of private colleges, business schools, and vocational institutes offering courses in mathematics, business management, computer science, and other skills allied to industrial engineering.
- 925 PETERSON'S GUIDES. (Updated annually; published by Peterson's, Box 2023, Princeton, NJ 08540.) A series of useful guides widely marketed. Of particular interest:
 - 930 Guide to Two-Year Colleges
 - 935 Guide to Four-Year Colleges
 - 940 Graduate and Professional Programs: an Overview
 - 945 Graduate Programs in Engineering and Applied Sciences.

Information on correspondence courses:

- 950 National University Continuing Education Association (NUCEA), 1 Dupont Circle, N. W., Washington, DC 20036. Offers a brochure listing the correspondence course offerings of 69 accredited
955 colleges and universities. Also compiles a GUIDE TO INDEPENDENT STUDY THROUGH CORRESPONDENCE INSTRUCTION, published by Peterson's (\$4.50; see no. 925 for address).
- 960 National Home Study Council, 1601 18th Street N. W., Washington, DC 20009. Publishes THERE'S A SCHOOL IN YOUR MAILBOX (\$4).

AUTHOR/TITLE INDEX TO BIBLIOGRAPHY

ABI/INFORM, 765
ACE (American Council on Education), 910
Akers, Herbert, 445
Algebra Simplified and Self-Taught, 200
Aluri, Rae, 460
American Council on Education, 910
American Machinist Manufacturing Cost Estimating Guide, 085
American National Standards Institute, 465
American Society for Metals, 550, 790, 795
American Society of Mechanical Engineers, 475
American Technical Publishers, 860
American Universities and Colleges, 910
American Welding Society, 865
ANSI, 465
Apple, J. M., 305
Applied Science and Technology Index, 470, 770
Art of Writing Business Reports and Proposals, 275

Barnes, Ralph M., 025
Baumeister, E., 475
Baumeister, Theodore, 342
Berdie, Douglas R., 065
Bibliographic Retrieval Service (BRS), 815
Blue Book, College, 915
Boeckh Computerized Building Costs, 780
Boley, Jack W., 370
Boodman, David M., 400
Books in Print, Subject Guide, 570
Boolean logic in database searching, 745
BRS (Bibliographic Retrieval Service), 815
Building Construction Cost Data, 480
Burbank, James A., 087

CAD/CAM Handbook, 250
Cahners Publishing Co., 870
Carpentry Handbook (Engineered Performance Standards), 110
Carson, Gordon B., 255, 345, 425
Chase, Kenneth, 394
Chen, Ching-Chi., 485
Clark, J., 210
College Blue Book, 915
Communicating with Graphics, 280
COMPENDEX, 775
Complete Handbook of Personal Computer Communications, 755
Complete Machine-Hour Rate System for Cost Estimating and Pricing, 090
Computer Data and Database Source Book, 760
Computerized Building Costs, E. H. Boeckh, 780
Continuing Education, 910-960
Correspondence Courses, 950-960
Courses, 910-960
Critical Path Management, 430

Databases, Searching Online, 735-810
Davies, Owen, 750
Developing Work Standards, 0363
DIALOG Information Services, Inc., 820
Dodge Building Cost Services, 490

Downing, D., 210
Dunns, Cal W., 070

E. H. Boeckh Computerized Building Costs, 780
EASYNET, 740
Edelhart, Mike, 750
Education, Continuing, 910-960
Educational Film Locator, 845
Electric, Electronic Handbook (Engineered Performance Standards), 115
Electrical Engineers, Standard Handbook, 505
Electronics Industry Cost Estimating Data, 087
Elements of Style, 295
Emergency/Service Handbook (Engineered Performance Standards), 120
Encyclopedia of Associations, 495
Engineered Performance Standards series, 100-180
Engineering Graphics, 240
Engineering Index, 500
Engineering Literature Index, 777
Estes, W. U., 440

F. W. Dodge Building Cost Services, 490
Filley, Richard D., 280
Films, 840-855
Fink, Donald, 505
Forms Analysis: A Management Tool for Design and Control, 455
Forms for the '80's: How to Design and Produce Them, 450
Frieder, David, 200
Fundamental Accounting Principles, 271

Geis, Irving, 225
General Electric Information Services, 825
General Industry, OSHA Safety and Health Standards, 385
General Services Administration, 575
Glossbrenner, Alfred, 755
Gondin, William K., 190
Government Manual, 580
Graduate and Professional Programs, 940
Graduate Programs in Engineering and Applied Sciences, 945
Guide to Effective Industrial Safety, 370
Guide to Four-year Colleges, 935
Guide to Independent Study through Correspondence Instruction, 955
Guide to Two-year Colleges, 930
Guide to U. S. Government Scientific and Technical Resources, 460
Gulf Publishing Company Video, 850

H. W. Wilson Co., 835
Handbook of Electronics Industry Cost Estimating Data, 087
Handbook of Industrial Engineering, 015, 055, 320, 335, 360,410
Hayslett, H. T., 195
Heating, Cooling, and Ventilation Handbook (Engineered Performance Stds.), 125
Hicks, Philip E., 020
Hillman, Howard, 275
How to Lie with Statistics, 225
How to Solve Statistical Problems with Your Pocket Calculator, 230
How to Write Scientific and Technical Papers, 300
Huff, Darrell, 225
Human Factors Design Handbook, 340
Human Factors: Understanding People-System Relationships, 310

ES Lighting Handbooks, 315
 IE, 010, 280, 510, 515, 875
 Illuminating Engineering Society of North America, 315
 LO, 040
 Index of Federal Specifications, Standards, and Commercial Item Descriptions, 575
 Industrial Engineering (journal of HE), 515
 Industrial Engineering and Management Press, 875
 Industrial Engineering Handbook, 005, 050, 075, 355, 405
 Industrial Engineering Indices, 510
 Information U. S. A., 525
 Institute of Industrial Engineers, 010, 280, 510, 515, 875
 Institute of Industrial Engineers, Methods Engineering, 010
 Intermediate Algebra and Analytic Geometry, 190
 International Labour Organisation, 040
 International Training Co., 850
 Introduction to Industrial Engineering and Management Science, 020
 Introduction to Work Study, 040
 Iwin, Richard D. (publisher), 895

Janitorial Handbook (Engineered Performance Standards), 130
 Jenner, Robert K., 087
 John Wiley & Sons, 905
 Journal of Ship Production, 520
 Juran, Joseph M., 395

Kantowitz, Barry H., 310
 Kemp, Jerrold E., 285
 Krouse, John K., 245

Lang, Douglas W., 430
 Larkin, J. A., 045
 Larson, Kermit D., 271
 Leenders, Michael R., 350
 Lesko, Matthew, 525, 760
 Lighting Handbook, 315
 Lockheed DIALOG, 820

Machinability Data Center, 080
 Machine Shop, Machine Repairs Handbook (Engineered Performance Standards), 135
 Machine-Hour Rate System for Cost Estimating and Pricing, Complete, 090
 Machinery's Handbook, 555
 Machining Data Handbook, 080
 Made Simple series (Doubleday), 185-195
 Magee, John F., 260, 400
 Making Successful Presentations, 290
 MARDATA, 785
 Marine Industry Data Bases, 785
 Marks' Standard Handbook for Mechanical Engineers, 342
 Masonry Handbook (Engineered Performance Standards), 140
 Mathematics (Sperling & Stuart), 185
 Maynard, H. B., 005, 050, 075, 320, 355, 405
 McGraw-HM address, 880
 McGraw-Hill Dictionary of Scientific and Technical Terms, 530
 McGraw-Hill Encyclopedia of Energy, 540
 McGraw-Hill Encyclopedia of Engineering, 545
 McGraw-Hill Encyclopedia of Science and Technology, 535
 Mechanical Engineers, Standard Handbook, 475
 METADEX, 790
 Metals Data File, 795
 Metals Handbook, 550

Methods Engineering Workshop for the Shipbuilding Industry, 010
Microfiche library, SNAME, 565
Moder, Joseph J., 435
Modern Mailroom Management, 445
Moffat, Donald W., 341
Moore, James M., 325
Motion & Time Study (Barnes), 025
Motion & Time Study (Mundel), 030
Motion & Time Study (Niebel), 035
Moving, Rigging Handbook (Engineered Performance Standards), 145
Mundel, Marvin E., 030
Muther, Richard, 330

NAHB, 480
National Association of Home Builders, 480
National Electrical Manufacturers Association, 855
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National Institute for Occupational Safety and Health, 390
National Shipbuilding Research Program, 565
National Standards Association, 810
National Technical Information Service, 800
National University Continuing Education Association, 950
National Video Clearinghouse, Inc., 840
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Niebel, Benjamin W., 035
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NTIS, 800
NUCEA, 950

Oakes, William S., 036
Oberg, Erik, 555
Occupational Education (segment of College Blue Book), 915
Occupational Safety and Health Administration, 375
OMNI Online Database Directory, 750
Online databases, 735-810
OSHA, 375
Osteen, Carl E., 455
Ostwald, Philip F., 085

Paint Handbook (Engineered Performance Standards), 150
Penton/IPC, 885
Performance Standards, Engineered, 105
Peterson's Guides, 925-945
Phillips, Cecil R., 435
Pipefitting, Plumbing Handbook (Engineered Performance Standards), 155
Planning and Producing Audiovisual Materials, 285
Plant Layout & Design, 325
Plant Layout and Materials Handling, 305
Practical Plant Layout, 330
Prentice-Hall, 890
Preventive/Recurring Maintenance Handbook (Engineered Performance Stds.), 160
Production Handbook, 255, 345, 425
Production Manager's Handbook of Formulas and Tables, 060, 095, 270, 365, 420
Production Planning & Control Handbook, 415
Production Planning and Inventory Control, 260, 400
Professional Interviewing, 070
Project Management with CPM and PERT, 435
Publisher's catalogs, 860-905

Purchasing and Materials Management, 350
 Pyle, William W., 271

 Quality Control Handbook, 395
 Questionnaires: Design and Use, 065

 Raines, Gar, 450
 Richard D. Irwin, 895
 Roads, Grounds, Pest Control & Refuse Collection H'bk (Eng. Perf. Stds.), 165
 Robinson, J., 460
 Rowntree, Derek, 220
 Ruskin, A. M., 440

 salvendy, Gavriel, 015,055, 335, 360,410
 Sampler on Sampling, 235
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 SDC Information Services, 830
 Searching online databases, 735-810
 Sharp, Vicki F., 230
 Sheet Metal, Structural Iron & Welding Handbook (Eng Perf Stds), 170
 Ship Production, Journal of, 520
 Shipyard Industry, OSHA Safety and Health Standards, 380
 Shupe, D. S., 265
 Smith, Terry C., 290
 SNAME, 21, 86,520
 Society of Naval Architects and Marine Engineers, 21, 86, 520
 Sohmer, Bernard, 190
 Spence, William P., 240
 Sperling, Abraham, 185
 Standard Handbook for Electrical Engineers, 505
 Standard Handbook for Mechanical Engineers, 475
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 Statistics (Downing & Clark), 210
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 Statistics Simplified and Self-Taught, 205
 Statistics Without Tears, 220
 Stearn, Stanley H., 205
 Strunk, William, Jr., 295
 Stuart, Monroe, 185
 Subject Guide to Books in Print, 570
 Synapse Books, 900
 Szoka, Kathryn, 280

 Taylor, Theodore, 087
 Teicholz, Eric, 250
 There's a School in Your Mailbox 960
 Trelease, Sam, 300
 Tucker, Spencer A., 090

 U. S. General Services Administration, 575
 U. S. Government Manual, 580
 U. S. National Technical Information Service, 800
 U. S. Occupational Safety and Health Administration, 375
 Unit Price Standards Handbook (Engineered Performance Standards), 175

 Value Engineering, 091
 Video Source Book, 840, 846

Wharfbuilding Handbook (Engineered Performance Standards), 180
What Every Engineer Should Know about Computer-Aided Design, 245
What Every Engineer Should Know About Economic Decision Analysis, 265
What Every Engineer Should Know About Project Management, 440
White, E. B., 295
Wiley (publisher), 905
Williams, William H., 235
Wilson, Frank C., 415
Wilsonline, 835
Woodson, Wesley E., 340
Work Study, 045

Zeyher, Lewis R., 060,095,270, 365,420

TRAINING GUIDES FOR SHIPYARD INDUSTRIAL ENGINEERING

CONTENTS

- I. Introduction to the Training Guides
- II. Training Guides
 - 1. For employees promoted from waterfront jobs to Industrial Engineering department.
 - 2. For technicians with some limited Industrial Engineering experience.
 - 3. For qualified Industrial Engineers who are new to shipyards after experience in other industries or graduation from Industrial Engineering schools.
 - 4. For managers and supervisors who will be indirectly affected by an Industrial Engineering study.
 - 5. For employees enrolled in Supervisor Training Course.
 - 6. For Industrial Engineering employees who want to increase their knowledge.(Questionnaire)
 - 7. For employees required to have thorough understanding of Industrial Engineering applications in shipyards.

I. Introduction to the Training Guides

The curriculum was developed to indicate the body of knowledge which an Industrial Engineer should understand in order to function professionally in all areas of a shipyard. However, many of the employees in Industrial Engineering departments already have some of the knowledge and skills covered by the curriculum. Other employees will receive assignments requiring only limited skills. Consequently, these guides are written to assist in matching material from the curriculum to special segments of the user community. The descriptions of the groups are to be taken very broadly since few people will really fall into the classifications as described.

Figure TG-1 shows the format of the guides and gives a brief explanation of the information contained. Individuals may want to use the "Time" column as a general guide to the emphasis which should be placed on material in each module.

Some Departments have found it beneficial to encourage On-The-Job-Training utilizing experienced supervisors in the role of Instructors. All the subjects recommended by the Training Guide are covered in a regular training schedule, but the classroom time is integrated with planned work assignments which require use of the material covered in the classroom. This approach requires much more work on the part of the instructor, but the results are often very beneficial to the student. Instructors are encouraged to utilize the types of enhancements which best suit their teaching style, the subject material and the participating audience.

TRAINING GUIDE 1:

Employees promoted from waterfront jobs to
Industrial Engineering Departments.

Previous Shipyard Experience:

Generally these employees have good waterfront knowledge and understand shipbuilding terms.

Previous Industrial Engineering Experience

Minimal.

SUBJECT	MODULE.	TIME	ENHANCEMENTS
An Introduction to Industrial Engineering.	I	2.0-4.0	Pre-Training test.
Industrial Engineering Methods	II	1.0-2.0	Include Shipyard illustrations of good and not so good applications. Ask audience for illustrations from their experience.

FIGURE TG-1 Training guide format with explanatory comments.

TRAINING GUIDE 1.

Employees promoted from waterfront jobs to Industrial
Engineering Department

PREVIOUS SHIPYARD EXPERIENCE

Generally these employees have good waterfront experience and understand shipbuilding terms.

PREVIOUS INDUSTRIAL ENGINEERING EXPERIENCE

Minimal.

SUBJECT	MODULE	CLASS HOURS	TEACHING ENHANCEMENTS
An Introduction to Industrial Engineering	I	2.0-4.0	Administer Pre-training test. Hand out Course Outline, Schedule, Evaluations Sheets, I. E. Definitions,
Industrial Engineering Methods	II	1.0-2.0	Include shipyard illustrations. Ask students to contribute their illustrations to be sure they comprehend the point.
Collecting Data Internal	III-1	2.0-6.0	Have group utilize technique under discussion. Calculate required sample size when practicing sampling. Emphasize methods used in yard.
External	III-2	0.5-1.0	Save data for use in Modules IV and V.
I. E. Forms	III-3	0.2-0.6	Emphasize forms most relevant to work student will be given. Hand out "Guide to Forms" which includes completed examples.
Verification	III-4	0.1-0.2	Suggest typical sources which are available through Yard.
Analyzing Information What to Look For.	IV-1	0.2-0.4	Use tests to help individuals discover whether they more readily recognize differences, similarities, trends, or aberrations.
Mathematical Methods	IV-2a, b, c, h	0.5-1.0	Use quick review test to determine areas of weakness. Respond to individual needs.
More Complex Mathematical Methods	IV-2 d, e, f, g, i	0.1-0.5	Have students recognize these methods exist and know when to ask for assistance.
Electronic Assistance, Software	IV-2 j, k	As Req.	Deal with these subjects only to the extent that department has standardized equipment.

SUBJECT	MODULE	CLASS HOURS	TEACHING ENHANCEMENTS
Graphical Solutions	IV-3	0.5.1.3	Emphasize basic graphic techniques. Handout sample graphs to illustrate good and poor techniques and formats.
Financial Analysis	IV-4	0.4-1.0	Provide company approved model. Cover simple applications especially equipment payback. Plant accountant might help teach this session.
Electronic Assistance	IV-3	0.0	Not recommended unless specific word processing or data manipulation skills are needed for assignments.
Data Presentation	v	1.0-2.0	Hand out examples of good and bad presentations of the same data. Introduce available references from bibliography. Highlight documentation, audit trail, departmental filing system. Summarize characteristics of a good presentation.
Application of Industrial Engineering Methods to Shipyards	VI	1.0-2.0	Explain what is being done at this yard and other yards. Forecast additional applications
Application to Planning and Scheduling	VII	1.0-4.0	This is a key section. Lace lecture with illustrations. Ask questions to ensure understanding by all participants. Assign homework assignment which provides lead into Module VIII.
Application to Production Control	VIII	1.5-3.0	Tie this Module closely to Module VII by review at start of class.
Application to Other Trades	IV	0.5-3.5	Good opportunity for classroom problem to extend previous lessons to new area. Use teams if class is large enough. Administer post-training test. Obtain evaluation of class.

Minimum = 12.5 hours
Maximum = 32.5 hours

TRAINING GUIDE 2.

his
ely
ter
Technicians with some mited Industrial Engineering Experience.

PREVIOUS SHIPYARD EXPERIENCE:

At least one year broad waterfront assignments.

PREVIOUS INDUSTRIAL ENGINEERING EXPERIENCE:

At least four month of industrial engineering experience with exposure to several types of projects.

SUBJECT	MODULE	CLASS HOURS	TEACHING ENHANCEMENTS
Introduction to Industrial Engineering	I	0.2-0.4	Rapid review by asking questions.
Industrial Engineering Methods	H	02-0.4	Rapid review by asking questions.
Collecting Data	III	0.2-0.5	Rapid review by asking questions. Also an opportunity to introduce new data sources.
Analyzing Information	IV	0.3-0.7	Emphasize Sections 2d, e, f, g, j, k. Include 3b, c, e; 4, 5, if necessary.
Data Presentation	v	0.2-0.4	Critique reports written by the Department during the past 6 months. Develop ideas for improvements.
Application of Industrial Engineering Methods to Shipyards	VI	0.2-0.4	Critique methods used in the past 6 months and identify combinations of methods which have been used effectively.
Application to Planning and Scheduling	VII	0.0-2.0	If possible, use this opportunity to enhance quality of input by I.E.'s into Planning and Scheduling system.
Application to Production Control	VIII	0.0-1.0	If possible, use this opportunity to enhance quality of input by I.E.'s into Planning and Scheduling system.
Application to Other Trades	I x	0.0-1.0	Cover this subject if there are opportunities to assist other trades.

Minimum = 1.3 hours
Maximum = 6.8 hours

TRAINING GUIDE 3.

Qualified Industrial Engineers who are new to shipyards after experience in other industries or graduation from Industrial Engineering schools.

PREVIOUS SHIPYARD EXPERIENCE:

None

PREVIOUS INDUSTRIAL ENGINEERING EXPERIENCE:

Reasonable diversified experience in similar industries or graduation with a Degree or Certificate in Industrial Engineering.

SUBJECT	MODULE	CLASS HOURS	TEACHING ENHANCEMENTS
Introduction to Industrial Engineering	I-3	1.0-3.0	Set tone for relationship with shipyard.
Introduction to Industrial Engineering Terms	II-1	0.1-0.3	Explain shipyard terms using pictures, sketches, photographs, etc. Follow with a walk-through of yard. Hand out definitions of terms.
Collecting Data	III-1	0.1-0.3	Introduction to shipyard Management Information System with comments on data quality and timeliness. Hand out list of available reports showing information in each.
Collecting Data	III-2	0.1-0.2	Introduction to Department and Shipyard Library. Review data available to Industrial Engineers.
Collecting Data	III-3	0.1-0.5	Introduction to Department forms, procedures, etc.
Data Presentation	v	0.1-0.3	Aids available for preparing presentations.
Introduction to Applications of Industrial Engineering Methods for Shipyards	VII	0.2-1.0	Include organizational charts, position descriptions, resume of key employees. Arrange to introduce new Industrial Engineer to line and staff managers.
Application to Planning and Scheduling	VII	2.0-3.0	Include explanation of cost control role of planning, budgeting, scheduling, and production reporting.
Application to Production Control	VIII	0.2-1.0	Include all controls.

SUBJECT	MODULE	CLASS HOURS	TEACHING ENHANCEMENTS
Application of Planning and Production Control to Support Trades	IX	0.1-2.0	Explain status of Production Control over Support Trades.
Minimum = 4.0 hours Maximum = 11.6 hours			

TRAINING GUIDE 4.

Managers and supervisors who will be indirectly affected
by an Industrial Engineering study.

PREVIOUS SHIPYARD EXPERIENCE:
Not Required

PREVIOUS INDUSTRIAL ENGINEERING EXPERIENCE:
Not Required

SUBJECT	MODULE	CLASS HOURS	TEACHING ENHANCEMENTS
Understanding the Industrial Engineering Approach to Problem solving	I-1a, b, c II-1 III-3a, b VI-1	0.3-0.8	Use dramatic shipyard examples of successful I. E. approaches to which audience will easily relate. Use Handout of Industrial Engineering terminology.
Industrial Engineering Methods	HI As Below		Explain the methods which will be used during the study.
Direct Observation	III-1b	0.2-0.6	Have group time and pace rate demonstrated activity.
Predetermined Times	III-1c, d	0.2-0.7	Have group apply times to demonstrated activity.
Sampling	III-1e	0.2-0.5	Have group participate in sampling of shop activity.
Historical Data	III-1f	0.2-0.6	Use example in which wrong conclusion is reached because data is incorrect. Arrange for class to catch the error. Emphasize need for accurate reporting.
Brainstorming	III-1g	0.2-0.3	Follow rules rigidly. Be sure creative person is prepared and involved. If necessary assign roles in advance.
External Sources	III-2	0.1-0.2	Hand out some comparisons based on external data.
Data Presentation	III-3 v	0.1-0.2	Explain any I. E. forms or unfamiliar presentation material which is apt to be used in reprot on the study.

Minimum = 1.5 hours
Maximun = 3.9 hours

TRAINING GUIDE 5.

Employees enrolled in Supervisor Training Course.

PREVIOUS SHIPYARD EXPERIENCE:

Some

PREVIOUS INDUSTRIAL ENGINEERING EXPERIENCE:

None

SUBJECT	MODULE	CLASS HOURS	TEACHING ENHANCEMENTS
Itroduction Industrial Engineering	I	0.1-0.2	Select material to fit audience. Provide terminology outline.
Industrial Engineering Methods	II	0.2-0.3	Select material to fit audience.
Collecting Data	III	0.1-0.2	Emphasize scientific nature of I. E. studies. Explain I. E. terminology very briefly. Use Handout.
Introduction to Application of Industrial Engineering Methods to Shipyards	VI	0.1-0.4	Explain how Industrial Engineering contributes to management control.

Minimum = 0.5 hours

Maximum = 1.1 hours

TRAINING GUIDE 6.

Industrial Engineering employees who want to increase their knowledge.

PREVIOUS SHIPYARD EXPERIENCE:

One year or more

PREVIOUS INDUSTRIAL ENGINEERING" EXPERIENCE:

Six months or more with several assignments

it is recommended that the full curriculum be used as a check list for employees to indicate the material in which they would benefit by having additional training. Tabulate the results of the questionnaire and use that as the basis for the instruction. The managers of the I.E. Department may want to evaluate the data to keep the training comparable with departmental goals.

The following questionnaire might be useful to determine material which should be included.

Module and sub-module		How much detail would you like on this subject?			
		OMIT	REVIEW BRIEFLY	REVIEW THOROUGHLY	NEW MATERIAL
SUBJECT		0 HOURS	.1 TO .5 HOURS	.6 TO 1.8 HOURS	COVER to UNDERSTANDING
I.	INTRODUCTION TO INDUSTRIAL ENGINEERING. 1. HISTORY 2. WHAT IS INDUSTRIAL ENGINEERING 3. COMMUNICATING				
II.	INDUSTRIAL ENGINEERING METHODS 1. ATTITUDE 2. OPERATIONAL METHODS				
III.	COLLECTING DATA 1. INTERNALLY GENERATED DATA 2. EXTERNAL DATA SOURCES 3. I.E. FORMS 4. SOURCES OF VERIFICATION				
IV.	ANALYZING INFORMATION 1. WHAT TO LOOK FOR 2. MATHEMATICAL METHODS 3. GRAPHICAL SOLUTIONS 4. FINANCIAL ANALYSIS 5. ELECTRONIC ASSISTANCE				
v. "	DATA PRESENTATION 1. ORGANIZING DATA 2. PRESENTATIONS TO GROUPS 3. SALES ROLE OF I. E. 4. DEVELOPING DOCUMENTS FOR ROUTINE COMMUNICATIONS				
VI.	APPLICATION OF I. E. METHODS OF SHIPYARDS 1. CREATING UNDERSTANDING 2. TRANSFERRING KNOWLEDGE FROM RELATED INDUSTRY				

SUBJECT	OMIT 0 HOURS	REVIEW BRIEFLY .0 TO .5 HOURS	REVIEW THOROUGHLY .6 TO 1.8 HOURS	MATERIAL COVER TO UNDERSTANDING
VII. APPLICATION TO PLANNING AND SCHEDULING				
1. INTRODUCTION				
2. PREDETERMINED METHODS				
3. DEVELOPING MEANINGFUL BUDGETS				
4. SUCCESSFUL SCHEDULING				
5. SELECTING EQUIPMENT				
6. SAFETY				
7. QUALITY AND REPRODUCIBILITY				
8. MATERIAL REQUIREMENTS PLANNING				
9. AUTHORIZING THE PLAN				
VIII. APPLICATION TO PRODUCTION CONTROL				
1. MANAGEMENT CONTROL				
2. COMMUNICATING THE PLAN TO MANAGERS AND WORKERS				
3. DOCUMENTING ACCOMPLISHMENTS				
4. ANALYZING VARIANCES				
5. INITIATING CORRECTIVE ACTION				
IX. PLANNING AND PRODUCTION CONTROL FOR SUPPORT TRADES				

TRAINING GUIDE 7.

Employee required to have thorough understanding of Industrial Engineering applications in shipyards.

PREVIOUS SHIPYARD EXPERIENCE:

Understanding would be enhanced by one or more years of experience.

PREVIOUS INDUSTRIAL ENGINEERING EXPERIENCE:

Understanding would be enhanced by one or more years of experience.

SUBJECT	MODULE	CLASS HOURS	TEACHING ENHANCEMENTS
Introduction to Industrial Engineering	I	3.0-5.0	Administer pre-training test. Hand out Evaluation Sheets. Show films for historical overview. Require outside reading about Industrial Engineering contributions to management controls. Use handout of shipyard and industrial engineering terms.
Industrial Engineering Methods	II	2.0-4.0	Explain I. E. Operations Manual if available. Cover procedures and documentation.
Collecting Data	III	6.0-10.0	Use field assignment to practice methods discussed in classroom.
Analyzing Information	IV	6.0-10.0	Pass out ambiguous data for analysis. Evaluate results of work done by class working groups.*
Data Presentation	v	3.0-5.0	Have students give reports during subsequent classes.
Introduction to Applications of Industrial Engineering Methods for shipyards	VI	2.0-4.0	Class teams to develop lists of present and potential applications
Application to Planning and Scheduling	VII	6.0-10.0	Class teams to set up planning system for model yard.
Application to Production Control	VIII	3.0-5.0	Class teams to set up production control system for model yard
Application of Planning and Production Control to Support Trades	IX	3.0-5.0	Assign different trades to class teams with objective of maximizing cost and schedule benefits to total yard. Administer post-training test. Collect evaluation sheets.

Minimum = 34.0 hours
Maximum = 58.0 hours

INDUSTRIAL ENGINEERING CURRICULUM FOR SHIPYARDS

CONTENTS

I. Introduction to the curriculum

II. Curriculum

Part A. Skill Acquisition

Module	I.	An Introduction to Industrial Engineering
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Module	II.	Industrial Engineering Methods
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Module	III.	Collecting Data
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Module	IV.	Analyzing Information
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Module	V.	Data Presentation
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Part B. Application to Shipyards

Module	VI.	Introduction to Application of Industrial Engineering Methods for Shipyards
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Module	VII.	Application to Planning and Scheduling
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Module	VIII.	Application to Production Control
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Module	IX.	Applying Planning and Production Control to the Support Trades
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1. Introduction to the Curriculum

The Curriculum is organized into two major sections. The first, divided into five modules, presents industrial engineering skills of special value to industrial engineering technicians and to professionals from other disciplines. The second section is divided into four modules which offer training in how to apply industrial engineering skills to shipyard applications.

The content of the five Skill Acquisition Modules has been selected for its direct relevance to shipyard situations, especially those identified in the List of Shipyard Problems found in the earlier part of this Guide and those identified in the shipyard survey undertaken at the onset of this project. Quite clearly, it was not the intent of the Curriculum to provide training in all skills used by industrial engineers. However the curriculum was designed to provide a basic “tool box” of the skills most frequently required in shipyard applications, covering perhaps 85% of the problems assigned to the industrial engineering department.

The subject material for the four Application to Shipyard Modules has been selected to provide a broad range of examples for shipyard use of industrial engineering skills. The survey did not reveal that all of the applications are in use in U.S. yards at this moment, although all the applications are found in related industries. It is worthy of note that all of the applications have cost saving potential to U. S. yards.

The Training Guides, found in another section of this Guide, provide some guidance to the relative degree of detail with which each subject should be treated.

II. Curriculum Modules

Part A. Skill Acquisition

MODULE I. AN INTRODUCTION TO INDUSTRIAL ENGINEERING

Note: This module may also be used to brief managers who will have only a peripheral relationship to the Industrial Engineering Program. See the Training Plan for further guidance in this matter.

1. History

a) Historic Perspectives. How industrial engineering started. What stimulated the early pioneers to action.

b) The rise of the professional industrial engineer. Changes in the role of line to staff function. Development of improved analytical tools.

c) Realization that the most profitable solution involved examining the impact on the total system. Description of the change in organizational relationships for the industrial engineering function which resulted from this.

2. What is Industrial Engineering?

a) What do Industrial Engineers really do and why does it take them so long?

b) Are I. E.'s really different?

c) How does Industrial Engineering differ from common sense?

d) Role of the Industrial Engineer in the integrated manufacturing system.

e) How to evaluate an Industrial Engineering project.

3. Communicating

a) Industrial Engineering terminology for shipyards. A clear explanation of the most important technical words in the industrial engineering vocabulary as applied in the shipyard. Include illustrative example for repair and new building operations.

b) How this terminology relates to shipyards. “

c) How the non-I.E. can benefit by thinking like an Industrial Engineer.

MODULE II. INDUSTRIAL ENGINEERING METHODS

1. Attitude

- a) Professionalism
- b) Accuracy and impartiality
- c) Integrity
- d) Company politics
- e) Sensitivity to others
- f) Role of emotions

2. Operational Methods for industrial Engineers

- a) Understanding I.E. position in company organization.
- b) Top level buy off of departmental priorities for use of I.E. resources.
- c) Clear definition of each task. Must understand needs of all affected parties.
- d) Adequate documentation of results. Organize the audit trail. Publish results.
- e) Arrange opportunities to answer questions and to explain recommendations.
- f) What questions to answer and what questions to avoid during the study period.
- g) Selecting the right level of detail for the data gathering and for presentations.
- h) Have the system report ongoing results. Set goals for the cognizant manager to commit to and then use reports to measure performance to those goals.
- i) Set personal performance goals.
- j) Keeping up to date.

MODULE III. COLLECTING DATA

1. Internally Generated Data

- a) Preparing others for the study
- b) Allowances
- c) When and how to use Direct (observation)
- d) Introduction to important predetermined time systems
- e) Selecting the appropriate predetermined times
- f) Sampling
 - Sample size, confidence level, appropriateness
 - Camera technique, teaming up with line supervisors
- g) Historical Data
 - Finding records to use
 - Evaluating accuracy
 - Determining Relevance
- h) Brainstorming and other group techniques.

2. External Data Sources

- a) Trade Journals, Professional articles, magazines and newspapers
- b) Library Search
- c) Telephone
- d) MARAD/SNAME
- e) Vendors
- f) Professional Associations
- g) Research by others
- i) Data base searches by others

3. Industrial Engineering Forms

- a) Multiple activity chart
- b) Flow Process Chart
- c) Operations Analysis
- d) Time Study Sheets
- e) Special Use Forms

4. Sources of Verification

- a) Published Ratios
- b) Unpublished Data
- c) Other sources

MODULE IV. ANALYZING INFORMATION

1. What to Look For

- a) Similarities
- b) Differences
- c) Trends
- d) Dealing with aberrations

2. Mathematical Methods

- a) Algebra
- b) Basic plane geometry
- c) Elemental solid geometry

- d) Simultaneous equations
- e) Combinations/permutations
- f) Elemental statistical analysis
- g) Handling inequalities
- h) Carrying units
- i) Understanding when to ask for help
- j) Using the electronic calculator
- k) Problem solving software

3. Graphical Solutions

- a) Linear graphs
- b) Non-linear graphs
- c) Nomography
- d) Scaled models and layouts
- e) Computer graphing

4. Financial Analysis

- a) Payback and capital recovery

5. Identifying and Evaluating Alternatives

- a) Method improvements
- b) Layout planning
- c) Material handling principles
- d) Alternative scheduling

6. Electronic Assistance

- a) Software available for data analysis
- b) CAD/CAM as a problem solving tool
- c) AUTOKON et al

MODULE V. DATA PRESENTATION

1. Organizing Data for Reports

- a) What to leave out
- b) What to include
- c) Level of detail

- d) The importance of a summary
- e) Use of color
- f) Ratio of words to visuals
- g) Role of graphs, charts, and illustrations
- h) Outline or report format. Before end of data collection period predict format but not the conclusions
- i) Making the report look professional
- j) Documentation and an audit trail

2. Presentations to Groups

- a) Flip charts
- b) Video tapes
- c) Overhead projectors
- d) Slides
- e) Movies
- f) Chalk boards
- g) Flannel boards
- h) Placards
- i) Models
- J) Real Objects
- k) Handouts

3. Sales Role of the Industrial Engineer

- a) Winning approval for the change
- b) Know the audience
- c) Losing gracefully

4. Developing Documents for Routine Communications

Part B. Application of Industrial Engineering to Shipbuilding and Ship Repair Yards

MODULE VI INTRODUCTION TO APPLICATIONS OF INDUSTRIAL ENGINEERING METHODS FOR SHIPYARDS

Note: This module may also be used to brief managers who will have only a peripheral relationship to the Industrial Engineering Program. See the Training Plan for further guidance in this matter.

1. Creating Understanding

- a) Shipyards are different
- b) Industrial engineering is a universal
- c) Requirements for a successful industrial engineering program in shipyards

2. Transferring knowledge of related industries to shipbuilding and repair

- a) Selecting the right combination of Industrial Engineering methods to match the problem.
- b) Establishing organizational relationships and avoid turf battles.
- c) ABCs. Always Be Certain solution solves the right problem
- d) Illustrations of Industrial Engineering contributions to shipyard profitability and risk management selected from Ship Producibility Research Program files.

MODULE VII. APPLICATION TO PLANNING AND SCHEDULING

1. Introduction

- a) Planning and Scheduling are not the same as Production Control
- b) Role of Planning in management of a shipyard
- c) The role of Production Control in the management of a shipyard
- d) Performance Standards and Performance Measurement
- e) Forecasting

2. Predetermining Methods

- a) Selecting the best method for performing the work.
- b) Identifying the need for a new method
- c) Selecting the preferred method
- d) Evaluating new technology
- e) Finding and justifying the right equipment
- f) Determining the total impact of method changes
- g) Work Center Capability Sheets
- h) Documentation and communication

3. Developing Meaningful Budgets

- a) Role of work method, material, and quality control at the previous operation on budget development
- b) Selecting the method to be used to set the budget
- c) How budgets should be used
- d) Budgets for each supervisor
- e) Budgets for shop loading
- f) Budgets for scheduling
- g) Budgets for bidding
- h) Budgets for preliminary estimating
- i) Budgets for cost comparisons
- j) Budget maintenance
- k) Documentation and communication
- l) Budgets for non-labor expenditures

4. Successful Scheduling

- a) Role of methods and budgets in establishing meaningful schedules
- b) Scheduling around interferences
- c) Line balancing
- d) Top-down vs bottom-up scheduling
- e) Successful multiple ship scheduling
- f) Identifying total cost of schedule changes
- g) Documentation and communication
- h) Illustrations

5. Selecting Facilities and Equipment

- a) Identifying the need
- b) Predicting the benefits
- c) Selecting the ideal solutions
- d) Documentation and communications
- e) Illustrations

6. Safety

- a) Implications of determining methods and standards
- b) Requiring concurrence from Safety Department

- c) Facing legal implications in advance of trouble
- d) Documentation and Communications
- e) Illustrations
- 7. Quality and Reproducibility
 - a) Role of Methods and Standards
- 8. Material Requirements Planning
 - a) Integration of scheduling, budgeting and material requirement planning
 - b) How to plan for “Just in Time”
- 9. Authorizing the Plan
- 10. Networking for Planning and Controlling
 - a) Networking Methods
 - b) Program Evaluation and Review Technique (PERT)
 - c) Critical Path Method
 - d) Project Planning Techniques
 - e) Balancing Work Stations

MODULE VIII. APPLICATION TO PRODUCTION CONTROL

- 1. The Essentials of Management Control
 - a) The role of a plan
 - b) Measurement of actual accomplishments
 - c) Corrective Action
- 2. Communicating the Plan to Controlling Managers and Workers
 - a) How to communicate systematically
 - b) The need for management buy-off
- 3. Documenting Accomplishments
- 4. Analyzing Variances
 - a) Accountability for analysis
 - b) Accountability for performance
- 5. Initiating Corrective Action
 - a) Where Industrial Engineers fit in

- b) The new plan
- c) Measuring results again

MODULE IX APPLICATION OF PLANNING AND PRODUCTION CONTROL TO SUPPORT TO SUPPORT TRADES

1. Making the returns commensurate with the efforts
2. Planning and Production Control
 - a) Methods
 - b) Budgets
 - c) Schedules
3. Potential for savings and risk control in material handling and rigging
 - a) Methods
 - b) Schedules
 - c) Budgets
 - d) Monitoring Performance
5. Special Opportunities in Plant Maintenance
 - a) By whom should maintenance be performed?
 - b) Documentation and communications
 - c) Monitoring

**SCHOOLS OFFERING DEGREES
IN
INDUSTRIAL ENGINEERING
NAVAL ARCHITECTURE
MARINE ENGINEERING**

CONTENTS

I. INTRODUCTION

II. METHODOLOGY

III. COMMENTS

STATE UNIVERSITIES

COMMUNITY COLLEGES AND OTHER INSTITUTIONS

CONTRACT INSTRUCTION

IV. RECRUITING INDUSTRIAL ENGINEERS

V. INFORMATION SOURCES

VI. LISTS OF SCHOOLS

INDUSTRIAL ENGINEERING SCHOOLS

NAVAL ARCHITECTURE SCHOOLS

MARINE ENGINEERING SCHOOLS

SCHOOLS FOR INDUSTRIAL ENGINEERING

I. INTRODUCTION

The purpose of this section is to identify schools which are likely to assist shipyards in training industrial engineers. The result of the investigation is a list of schools which offer industrial engineering degrees, a list of schools which offer naval architecture degrees and a list of schools which offer degrees in marine engineering. The lists are sorted by state to facilitate locating schools near to specific shiypards. The listings indicate the level of the curricula offered.

II. METHODOLOGY

In order to develop the school lists an extensive catalogue of schools was reviewed and a limited group identified; namely schools which offered industrial engineering, management engineering and plant engineering curricula. Letters were sent to these schools requesting catalogues with curricula information. Four hundred and ninety eight responses were received.

Next the information available from the sources referenced in Section V below was used to further refine the lists. Finally, during the interviews of the shipyards, queries were made about schools which supported shipyard industrial engineering training.

This refined list of 245 schools will not remain static because changes in course offerings take place routinely on campuses as part of ongoing evaluation programs. Users of the tabulations in the Appendix are likely to find that additions and deletions must be made to keep the list current.

III. COMMENTS

The following information about sources of instruction may prove useful to shipyards seeking assistance form colleges and universities. The charters of institutions vary greatly, and Trustees set very different goals to be met by the administration of each institution. Consequently administrative creativity that we have observed at one school might not be found at a similar institution at a differnet location, or even at the same institution at a different time.

The project identified State Universities, Community Colleges, and Contract Instruction as the most probable sources of assistance with industrial engineering training. A few words about each of the first three sources seems appropriate to this report.

STATE UNIVERSITIES

State schools often have several campuses, each located in an area of high population desity. Typically each campus has its own administrative staff with adequate authority to make curriculum decision. In addition to these semi-autonomous campuses, many schools also provide instruction in various local communities. Facilities may be owned or leased by the University or may be supplied through such local sources as municipal government or school systems. In some cases, industries or trade groups provide facilities in order to expedite training for their employees and others.

This responsiveness to public need opens the way for a state institution to offer industrial engineering instruction at a location convenient to yard employees. The curriculum can usually be modified to meet specific needs. It is very possible that the curriculum developed in other parts of this research task can form the basis for courses made available to shipyard employees wishing to become proficient in industrial engineering skills.

Some firms further support classes by underwriting costs and by guaranteeing part of the enrollment. In supporting public classes, the firms provide their industrial engineering trainees with exposure to industrial engineers from other industries so that an exchange can take place which will broaden the outlook of all involved.

COMMUNITY COLLEGES AND OTHER INSTITUTIONS

This category includes vocational and technical schools, two year institutions, and even some public school systems. Some of these institutions are privately owned and as their sole means of support offer classes

for which there is enough public demand. The staffing pattern in these schools often centers about a core group of faculty members, augmented by part-time instructors, who may possess special knowledge which could be of assistance to a yard desiring to improve its industrial engineering capabilities. Communicating with the community schools in your area may provide you with a broadly skilled faculty for your training programs.

CONTRACT INSTRUCTION

Many teachers are willing to prepare material and teach classes under a direct contract. The most obvious sources for such instructors are the schools in your area. Additionally, some businessmen enjoy classroom work and will work hard at teaching a class in their field. Contract fees are variable and depend upon how much preparation is required. Charges of \$20 to \$40 per class room hour are common.

Firms which have had the most success using contract teachers have found that two factors have a marked impact on the success of any program: determination of the goal for the student, and the communication of the specific goal to the instructor well in advance of the first class. It is important to seek out teachers whose pedagogical techniques best fit the situation. Sometimes a technically qualified person cannot impart that knowledge to the class in an interesting manner. The goal of education is to create understanding and classroom methods are important to achieving that goal.

IV. RECRUITING INDUSTRIAL ENGINEERS

One use for the lists of colleges and universities which accompany this report is to facilitate locating industrial engineering graduates for possible employment. The information sources in Section IV below may offer further assistance in this regard. Several of the people interviewed in this project mentioned that some industrial engineering courses focus on practical matters while others provide the students with greater theoretical skills. In selecting schools at which to recruit, consideration should be given to the type of work you expect the newly hired industrial engineer to do. Some schools offer potential employers an opportunity to evaluate a student in action through a work-study program.

All schools welcome inquiries about potential employment of their graduates. The Placement Offices at many institutions will notify you of candidates who meet the qualifications which you specify. In addition a call to a faculty member who teaches industrial engineering courses may help to identify students especially qualified for shipyard employment.

V. INFORMATION SOURCES

Several good source books exist which list accredited schools and describe the courses of instruction which they offer. Many of these directories are updated annually. The most recently updated material is probably the most beneficial. In our studies we were told of one school which was dropping industrial engineering from its published majors and of two schools which were adding industrial engineering as a major.

The books listed below are available through most good book stores and are often found in libraries or school guidance offices.

INDEX OF MAJORS; 6th Edition. (Published by College Entrance Examination Board, 888 Seventh Avenue, New York, N.Y. 10106; ISBN No. 0-87447-159-1; Cost \$10.59 in paper.) Includes listing of schools by major courses of study offered. Separated into section listing: 1) schools offering Associate Degrees and 2) schools offering Bachelor and Masters programs.

PETERSON'S ANNUAL GUIDE TO UNDERGRADUATE STUDIES: TWO YEAR COLLEGES; 14th Edition. (Published by Peterson's Guides, P.O. Box 2123, Princeton, New Jersey 08540; ISBN No. 0-87866-216-2) Listing of names, addresses and degrees offered by accredited two year schools in the U.S. Includes data on enrollment, application requirements and financial aid.

Cass, James and Birnbaum, Max; **COMPARATIVE GUIDE TO AMERICAN COLLEGES;** Revised Annually. (Published by Harper and Row, 10 East 53rd Street, New York, New York 10022; ISBN No. 0-06-015183-8; Cost \$12.95 in paper:) Contains accredited colleges listed by major courses of study.

BARRON'S PROFILES OF AMERICAN COLLEGES; Regional Editions. (Revised annually: published by College Division of Barron's Educational Services, Inc. 113 Crossway Parkway, Woodbury, New York 11791; ISBN No. 8120-2075-8; Produced in 4 regional editions; \$4.95 each in paper.) Reports on student life, programs of study, expenses, and admission requirements. Oriented towards the high school student applying for admissions.

BARRON'S PROFILES OF AMERICAN COLLEGES; Volume #1, Descriptions of colleges and Volume #2, Index of Major Areas of Study. (Revised annually: published by College Division of Barron's Educational Services, Inc. 113 Crossway Parkway, Woodbury, New York 11791; ISBN No;O-8120-2791~ Volume #1 costs \$8.95 in paper. Volume #2 costs 5.95 in paper.) A comprehensive guide to American Colleges and Universities. Similar to the regional edition except that these volumes cover the total U.S.

VI. LISTS OF SCHOOLS

The three lists which are appended identify the schools which are most likely to have a long term impact on industrial engineering in shipyards.

- A. Schools offering undergraduate or graduate degrees in Industrial Engineering or similar disciplines
- B. Schools granting degrees in Naval Architecture
- C. School granting degrees in Marine Engineering

The schools on List A, which recognize shipbuilding as relatively unpenetrated by industrial engineering methodology, might be willing to incorporate into their curriculum some courses which would familiarize industrial engineering students with the unique nature of the challenges for industrial engineers in shipyards. Case studies or class examples illustrating shipyard situations, or at least some exposure to the maritime terminology would certainly assist any industrial engineering student who will be offered a position in a shipyard or with a supplier of marine goods. Job opportunities in the shipyards can be a catalyst in effecting such additions to course material.

The schools on List A can serve as a resource for yards wishing to increase the industrial engineering knowledge among top managers. A well-versed professor speaking to a group of top level managers could provide an interesting insight into the benefits of industrial engineering work for ship repairs and construction.

Schools teaching naval architecture or marine engineering have by and large failed to educate degree candidates about industrial engineering. Even schools which offer both naval architecture and industrial engineering degrees have not integrated the two disciplines. Since the graduates of the schools on Lists B and C frequently ascent to influential management positions in the industry, efforts by these schools to reorient their curricula toward a better understanding of shipyard industrial engineering would be beneficial in the long term.

Over the past decade, research conducted under the guidance of the Ship Production Committee of the Society of Naval Architects and Marine Engineers, the Maritime Administration and the United States Navy has highlighted for many yards that industrial engineering is a valuable asset to shipyard management. It is to be hoped that a dialogue can be promoted between the schools training our future shipyard managers and influential SNAME members with the result that a course in industrial engineering methods becomes a part of the required curriculum at these prestigious school.

**SCHOOLS OFFERING DEGREES
IN
INDUSTRIAL ENGINEERING**

SCHOOL	LEVEL*
Alabama	
AUBURN UNIVERSITY Auburn Alabama 36849	B, M, D
JOHN C. CALHOUN STATE COMMUNITY COLLEGE Decatur Alabama 35602	A
UNIVERSITY OF ALABAMA University Alabama 35485	B, M
Alaska	
UNIVERSITY OF ALASKA-ANCHORAGE Anchorage Alaska 99504	M
UNIVERSITY OF ALASKA-FAIRBANKS Fairbanks Alaska 99701	M
Arizona	
ARIZONA STATE UNIVERSITY Tempe Arizona 85587	B, M, D,
NORTHERN ARIZONA STATE UNIVERSITY Flagstaff Arizona 86011	B
UNIVERSITY OF ARIZONA Tuscon Arizona 85721	B, M
Arkansas	
MISSISSIPPI COUNTY COMMUNITY COLLEGE Blytheville Arkansas 72315	A
UNIVERSITY OF ARKANSAS Fayetteville Arkansas 72701	B, M
California	
CALIFORNIA POLYTECHNIC STATE UNIVERSITY San Luis Obispo California 93407	B
CALIFORNIA STATE POLYTECHNIC UNIVERSITY Pomona California 91768	B
CALIFORNIA STATE UNIVERSITY-FRESNO Fresno California 93740	B

*A = Associate B = Bachelor M = Masters D = Doctorate

SCHOOL	LEVEL*
CALIFORNIA STATE UNIVERSITY-LONG BEACH Long Beach California 90840	B
CALIFORNIA STATE UNIVERSITY-NORTHRIDGE Northridge California 91324	B
CHABOT COLLEGE Hayward California 94545	A
CUESTA COLLEGE San Luis Obispo California 93403	A
CUYAMACA COLLEGE El Cajon California 92020	A
DE ANZA COLLEGE Cupertino California 95014	A
FULLERTON COLLEGE Fullerton California 92634	A
KING'S RIVER COMMUNITY COLLEGE Reedley California 93654	A
LOS ANGELES HARBOR COLLEGE Wilmington California 90744	A
LOS ANGELES PIERCE COLLEGE Woodland Hills California 91371	A
SAN JOAQUIN DELTA COLLEGE Stockton California 95207	A
SAN JOSE STATE UNIVERSITY San Jose California 95192	B, M
SANTA ANA COLLEGE Santa Ana California 92706	A
STANFORD UNIVERSITY Stanford California 94305	B, M, D

*A = Associate B = Bachelor M = Masters D = Doctorate

SCHOOL	LEVEL*
UNITED STATES INTERNATIONAL UNIVERSITY San Diego California 92131	B
UNIVERSITY OF CALIFORNIA-BERKELEY Berkeley California	B, M, D
UNIVERSITY OF SANTA CLARA Santa Clara California 95053	M
UNIVERSITY OF SOUTHERN CALIFORNIA Los Angeles California 90007	B, M, D
UNIVERSITY OF THE PACIFIC Stockton California 95211	B
WEST COAST UNIVERSITY Los Angeles California 90020	B, M
Colorado COLORADO STATE UNIVERSITY Fort Collins Colorado 8053	B, M
Connecticut THAMES VALLEY STATE TECHNICAL COLLEGE Norwich Connecticut 06360	A
UNIVERSITY OF NEW HAVEN West Haven Connecticut 06708	B, M
WATERBURY STATE TECHNICAL COLLEGE Waterbury Connecticut 06708	A
Delaware	
Florida BREVARD COMMUNITY COLLEGE Cocoa Florida 32922	A
MANATEE JR COLLEGE Bradenton Florida 33507	A

*A = Associate B = Bachelor M = Masters D = Doctorate

SCHOOL	LEVEL*
UNIVERSITY OF CENTRAL FLORIDA Orlando Florida 32816	B, M, D
UNIVERSITY OF FLORIDA Gainesville Florida 32611	B
UNIVERSITY OF MIAMI Coral Gables Florida 33124	B, M
UNIVERSITY OF SOUTH FLORIDA Tampa Florida 33620	B, M, D
Georgia GEORGIA COLLEGE Milledgeville Georgia 31601	B
GEORGIA INSTITUTE OF TECHNOLOGY Atlanta Georgia 30332	B, M, D
GEORGIA SOUTHERN COLLEGE Statesboro Georgia 30460	B
MORRIS BROWN COLLEGE Atlanta Georgia 30313	B
SOUTH GEORGIA COLLEGE Douglas Georgia 31533	A
Hawaii	
Idaho	
Illinois BRADLEY UNIVERSITY Peoria Illinois 61625	B, M
CARL SANBURG COLLEGE Galesburg Illinois 61401	A
COLLEGE OF DUPAGE Glen Ellyn Illinois 92020	A

*A = Associate B = Bachelor M = Masters D = Doctorate

SCHOOL	LEVEL*
ILLINOIS CENTRAL COLLEGE East Preoria Illinois 61635	A
ILLINOIS EAST COMMUNITY COLLEGES-LINCOLN TRAIL Robinson Illinois 62454	A
ILLINOIS VALLEY COMMUNITY COLLEGE Oglesby Illinois 61348	A
MCHENRY COUNTY COLLEGE Crystal Lake Illinois 60014	A
MIDWEST COLLEGE OF ENGINEERING Lomard Illinois 60148	B, M
MILLIKIN UNIVERSITY Decatur Illinois 62522	B
NORTHWESTERN UNIVERSITY Evanston Illinois 60201	B, M, D
PARKLAND COLLEGE Champaign Illinois 61820	A
RICHLAND COMMUNITY COLLEGE Decatur Illinois 62526	A
ROCK VALLEY COLLEGE Rockford Illinois 61101	A
ROOSEVELT UNIVERSITY Chicago Illinois 60605	B
SOUTHERN ILLINOIS UNIVERSITY Edwardsville Illinois 62026	B
TRITON COLLEGE River Grove Illinois 60171	A
UNIVERSITY OF ILLINOIS-CHICAGO Chicago Illinois 60680	B, M

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SCHOOL	LEVEL*
UNIVERSITY OF ILLINOIS-URBANA/CHAMPAIGN Urbana Illinois 61801	B, M, D
Indiana BETHEL COLLEGE Mishawaka Indiana 46544	B
INDIANA INSTITUTE OF TECHNOLOGY Fort Wayne Indiana 46803	B
INDIANA U-PURDUE U AT INDIANAPOLIS Indianapolis Indiana 46202	M
INDIANA UNIVERSITY EAST Richmond Indiana 47374	A
INDIANA VOCATIONAL TECHNICAL INSTITUTE Sellersburg Indiana 47172	A
PURDUE UNIVERSITY-WEST LAFAYETTE West Lafayette Indiana 47907	B, M, D
TRI STATE UNIVERSITY Angola Indiana 46703	B
UNIVERSITY OF EVANSVILLE Evansville Indiana 47702	B
Iowa INDIAN HILLS COMMUNITY COLLEGE Ottumwa Iowa 52501	A
IOWA STATE UNIVERSITY Ames Iowa 50011	B, M, D
UNIVERSITY OF IOWA Iowa City Iowa 52242	B, M, D
Kansas ALLEN COUNTY COMMUNITY COLLEGE Iola Kansas 66749	A

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SCHOOL	LEVEL*
BUTLER COUNTY COMMUNITY COLLEGE El Dorado Kansas 67402	A
COFFEYVILLE COMMUNITY COLLEGE Coffeyville Kansas 67337	A
KANSAS STATE UNIVERSITY Manhattan Kansas 66506	B, M
WICHITA STATE UNIVERSITY Wichita Kansas 67208	B, M
Kentucky	
INSTITUTE OF ELECTRONIC TECHNOLOGY Paducah Kentucky 42001	A
MURRAY STATE UNIVERSITY Murray Kentucky 42071	B
UNIVERSITY OF LOUISVILLE Louisville Kentucky 40292	M
Louisiana	
LOUISIANA STATE UNIVERSITY AND A&M COLLEGE Baton Rouge Louisiana 70803	B, M
LOUISIANA TECHNICAL UNIVERSITY Ruston Louisiana 71272	B, M
UNIVERSITY OF SOUTHWESTERN LOUISIANA Lafayette Louisiana 70504	M
Maine	
Maryland	
CHESAPEAKE COLLEGE Wye Mills Maryland 21679	A
PRINCE GEORGE'S COMMUNITY COLLEGE Largo Maryland 20870	A

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SCHOOL	LEVEL*
UNITED STATES NAVAL ACADEMY Annapolis Maryland 21402	B
Massachusetts BOSTON UNIVERSITY Boston Massachusetts 02215	B, M
CENTRAL NEW ENGLAND COLLEGE Worcester Massachusetts 01610	B
EMMANUEL COLLEGE Boston Massachusetts 02115	B
GREENFIELD COMMUNITY COLLEGE Greenfield Massachusetts 01301	A
NORTHEASTERN UNIVERSITY Boston Massachusetts 02115	B, M
SPRINGFIELD TECHNICAL COMMUNITY COLLEGE Springfield Massachusetts 01105	A
UNIVERSITY OF MASSACHUSETTS-AMHERST Amherst Massachusetts 01003	B, M, D
WENTWORTH INSTITUTE OF TECHNOLOGY Boston Massachusetts 02115	A
WESTERN NEW ENGLAND COLLEGE Springfield Massachusetts 01119	B, M
WORCESTER POLYTECHNIC INSTITUTE Worcester Massachusetts 01609	B, M
Michigan ALPENA COMMUNITY COLLEGE Alpena Michigan 49707	A
GENERAL MOTORS INSTITUTE Flint Michigan 48502	B

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SCHOOL	LEVEL*
HENRY FORD COMMUNITY COLLEGE Dearborn Michigan 48128	A
KELLOG COMMUNITY COLLEGE Battle Creek Michigan 49016	A
LAKE MICHIGAN COLLEGE Benton Harbor Michigan 49022	A
LANSING COMMUNITY COLLEGE Lansing Michigan 48914	A
MUSKEGON COMMUNITY COLLEGE Muskegon Michigan 49442	A
SCHOOLCRAFT COLLEGE Livonia Michigan 48152	A
UNIVERSITY OF DETROIT Detroit Michigan 48221	M
UNIVERSITY OF MICHIGAN-ANN ARBOR Ann Arbor Michigan 48185	B, M, D
UNIVERSITY OF MICHIGAN-DEARBORN Dearborn Michigan 48202	B, M
WAYNE COUNTY COMMUNITY COLLEGE Detroit Michigan 48226	A
WAYNE STATE UNIVERSITY Detroit Michigan 48202	B, M, D
WESTERN MICHIGAN UNIVERSITY Kalamazoo Michigan 49008	B, M
Minnesota MOORHEAD STATE UNIVERSITY Moorhead Minnesota 56560	B

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SCHOOL	LEVEL*
ST CLOUD STATE UNIVERSITY St. Cloud Minnesota 56301	B
UNIVERSITY OF MINNESOTA-DULUTH Duluth Minnesota 55812	B
UNIVERSITY OF MINNESOTA-TWIN CITIES Minneapolis Minnesota 55455	B, M, D
Mississippi MERIDIAN JUNIOR COLLEGE Meridian Mississippi 39301	A
MISSISSIPPI STATE UNIVERSITY Mississippi State Mississippi 39762	B,M
Missouri ⁱ CROWDER COLLEGE Neosho Missouri 64850	A
JEFFERSON COLLEGE Hillsboro Missouri 63050	A
MINERAL AREA COLLEGE Flat River Missouri 63601	A
ST LOUIS COMMUNITY COLLEGE-FLORISSANT VALLEY St. Louis Missouri 63135	A
UNIVERSITY OF MISSOURI-COLUMBIA. Columbia Missouri 65211	B, M, D
UNIVERSITY OF MISSOURI-ROLLA Rolls Missouri 65401	B, M, D
WASHINGTON UNIVERSITY St. Louis Missouri 63130	M
Montana MONTANA STATE UNIVERSITY Bozeman Montana 59717	B, M

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SCHOOL	LEVEL*
Nebraska UNIVERSITY OF NEBRASKA-LINCOLN Lincoln Nebraska 68588	B, M, D
UNIVERSITY OF NEBRASKA-OMAHA Omaha Nebraska 68182	B
Neveda	
New Hampshire NEW HAMPSHIRE COLLEGE Henniker New Hampshire 03242	B
New Jersey CUMBERLAND COUNTY COLLEGE Vineland New Jersey 08360	A
FAIRLEIGH DICKINSON UNIVERSITY Teaneck New Jersey 07666	B
MIDDLESEX COUNTY COLLEGE Edison New Jersey 08817	A
NEW JERSEY INSTITUTE OF TECHNOLOGY Newark New Jersey 07102	B, M
PRINCETON UNIVERSITY Princeton New Jersey 08544	B
RUTGERS UNIVERSITY COLLEGE OF ENGINEERING New Brunswick New Jersey 08903	B
STEVENS INSTITUTE OF TECHNOLOGY Hoboken New Jersey 07030	B, M, D
TRENTON STATE COLLEGE Trenton New Jersey 08625	B
New Mexico NEW MEXICO STATE UNIVERSITY Los Cruces New Mexico 88003	B, M

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SCHOOL	LEVEL*
New York ALFRED UNIVERSITY Alfred New York 14802	B, M
CLARKSON COLLEGE Potsdam New York 13676	B
COLUMBIA UNIVERSITY-SCHOOL OF ENGINEERING & APPLIED SCIENCES New York New York 10022	B, M, D
CORNELL UNIVERSITY Ithaca New York 14853	B, M, D
CORNING COMMUNITY COLLEGE Corning New York 14830	A
GENESEE COMMUNITY COLLEGE Batavia New York 14020	A
HOFSTRA UNIVERSITY Hempstead New York 11550	B
HUDSON VALLEY COMMUNITY COLLEGE Troy New York 12180	A
MONROE COMMUNITY COLLEGE Rochester New York 14623	A
NASSAU COMMUNITY COLLEGE Garden City New York 11530	A
NEW YORK INSTITUTE OF TECHNOLOGY New York New York 10023	B
POLYTECHNIC INSTITUTE OF NEW YORK Brooklyn New York 11201	B, M, D
PRATT INSTITUTE Brooklyn New York 11205	B

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SCHOOL	LEVEL*
RENNESLAER POLYTECHNIC INSTITUTE Troy New York 12181	B, M
ROCHESTER INSTITUTE OF TECHNOLOGY Rochester New York 14623	B, M
SCHENECTADY COUNTY COMMUNITY COLLEGE Schenectady New York 12305	A
SUNY A&T COLLEGE-ALFRED Alfred New York 14802	A
SUNY A&T COLLEGE-CANTON Canton New York 13617	A
SUNY A&T COLLEGE-DELHI Delhi New York 13753	A
SUNY A&T COLLEGE-MORRISVILLE Morrisville New York 13408	A
SUNY-BUFFALO Buffalo New York 14214	B, M, D
SYRACUSE UNIVERSITY Syracuse New York 13210	B, M, D
North Carolina BLUE RIDGE TECHNICAL COLLEGE Flat Rock North Carolina 28731	A
CATAWBA VALLEY TECHNICAL COLLEGE Hickory North Carolina 28601	A
CRAVEN COMMUNITY COLLEGE New Bern North Carolina 28560	A
GASTON COLLEGE Dallas North Carolina 28034	A
HAYWOOD TECHNICAL COLLEGE Clyde North Carolina 28721	A

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SCHOOL	LEVEL*
LENOIR COMMUNITY COLLEGE Kinston North Carolina 28501	A
MARTIN COMMUNITY COLLEGE Williamston North Carolina 27892	A
NORTH CAROLINA A&T STATE UNIVERSITY Greensboro North Carolina 27411	B, M
NORTH CAROLINA STATE UNIVERSITY-RALEIGH Releigh North Carolina 27650	B, M, D
VANCE-GREENVILLE COMMUNITY COLLEGE Henderson North Carolina 27536	A
WAKE TECNICAL COLLEGE Raleigh North Carolina 27603	A
WAYNE COMMUNITY COLLEGE Goldsboro North Carolina 27530	A
North Dakota NORTH DAKOTA STATE UNIVERSITY Fargo North Dakota 58105	B, M
UNIVERSITY OF NORTH DAKOTA Grand Forks North Dakota 58201	B
Ohio BOWLING GREEN STATE U-FIRELANDS COLLEGE Huron Ohio 44839	A
CASE WESTERN RESERVE UNIVERSITY Cleveland Ohio 44106	B
CENTRAL OHIO TECHNICAL COLLEGE Newark Ohio 43055	A
CINCINNATI TECHNICAL COLLEGE Cincinnati Ohio 45223	A

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SCHOOL	LEVEL*
CLEVELAND STATE UNIVERSITY Cleveland Ohio 44114	B, M
EDISON STATE COMMUNITY COLLEGE Piqua Ohio 45356	A
JEFFERSON TECHNICAL COLLEGE Steubenville Ohio 43952	A
KENT STATE UNIVERSITY-ASHTABULA CAMPUS Ashtabula Ohio 44004	A
KENT STATE UNIVERSITY-SALEM CAMPUS Salem Ohio 44460	A
KENT STATE UNIVERSITY-TRUMBELL CAMPUS Warren Ohio 44483	A
KENT STATE UNIVERSITY-TUSCARAWAS CAMPUS New Philadelphia Ohio 44663	A
LAKELAND COMMUNITY COLLEGE Mentor Ohio 44060	A
LIMA TECHNICAL COLLEGE Lima Ohio 45804	A
LORAIN COUNTY COMMUNITY COLLEGE Elyria Ohio 44035	A
MARION TECHNICAL COLLEGE Marion Ohio 43302	A
MIAMI UNIVERSITY-MIDDLETOWN CAMPUS Middletown Ohio 45042	A
MICHAEL J. OWENS TECHNICAL COLLEGE Toledo Ohio 43699	A
NORTH CENTRAL TECHNICAL COLLEGE Mansfield Ohio 44901	A

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SCHOOL	LEVEL*
NORTHWEST TECHNICAL COLLEGE Archbold Ohio 43502	A
OHIO STATE UNIVERSITY Columbus Ohio 43210	B, M, D
OHIO UNIVERSITY Athens Ohio 45701	B, M
SINCLAIR COMMUNITY COLLEGE Dayton Ohio 45402	A
SOUTHERN STATE COMMUNITY COLLEGE Hillsboro Ohio 45133	A
TERRA TECHICAL COLLEGE Fremont Ohio 43420	A
UNIVERSITY OF CINCINNATI-CLEREMONT GENERAL & TECHNICAL COLLEGE Batavia Ohio 45103	A
UNIVERSITY OF CINCINNATI Cincinnati Ohio 45226	B, M, D
UNIVERSITY OF DAYTON Dayton Ohio 45409	M
UNIVERSITY OF TOLEDO Toledo Ohio 43606	A, B, M
YOUNGSTOWN STATE UNIVERSITY Youngstown Ohio 44555	B
Oklahoma NORTHERN OKLAHOMA COLLEGE Tonkawa Oklahoma 74653	A
OKLAHOMA CITY COMMUNITY COLLEGE Oklahoma City Oklahoma 73159	A

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SCHOOL	LEVEL*
OKLAHOMA STATE UNIVERSITY Stillwater Oklahoma 74078	B, M, D
OKLAHOMA STATE UNIVERSITY TECHNICAL INSTITUTE Oklahoma City Oklahoma 73107	A
UNIVERSITY OF OKLAHOMA Norman Oklahoma 73019	B, M, D
Oregon	
CHEMEKETA COMMUNITY COLLEGE Salem Oregon 97309	A
CLACKAMAS COMMUNITY COLLEGE Oregon City Oregon 97045	A
LANE COMMUNITY COLLEGE Eugene Oregon 97405	A
OREGON STATE UNIVERSITY Corvallis Oregon 97331	B, M, D
UNIVERSITY OF PORTLAND Portland Oregon 97203	B
Pennsylvania	
BUCKNELL UNIVERSITY Lewisburg Pennsylvania 17837	B
COMMUNITY COLLEGE OF ALLEGHENY COUNTY-ALLEGHENY Pittsburgh Pennsylvania 15212	A
DREXEL UNIVERSITY Philadelphia Pennsylvania 19104	M
GANNON UNIVERSITY Erie Pennsylvania 16541	B
GENEVA COLLEGE Beaver Falls Pennsylvania 15010	B

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SCHOOL	LEVEL*
GROVE CITY COLLEGE Grove City Pennsylvania 16127	B
LEHIGH UNIVERSITY Bethlehem Pennsylvania 18015	B, M, D
LUZERNE COUNTY COMMUNITY COLLEGE Manticoke Pennsylvania 18634	A
PENNSYLVANIA STATE UNIVERSITY University Park Pennsylvania 16802	B, M, D
PITTSBURGE TECHNICAL INSTITUTE Pittsburgh Pennsylvania 15236	A
READING AREA COMMUNITY COLLEGE Reading Pennsylvania 19603	A
SPRING GARDEN COLLEGE Chestnut Hill Pennsylvania 19118	B
UNIVERSITY OF PITTSBURGH Pittsburgh Pennsylvania 15260	B, M, D
UNIVERSITY OF PITTSBURGH-BIUDFORD Bradford Pennsylvania 16701	B
WILKES COLLEGE Wilkes-Barre Pennsylvania 18766	B
YORK COLLEGE OF PENNSYLVANIA York Pennsylvania 17405	B
Rhode Island ROGER WILLIAMS COLLEGE Bristol Rhode Island 02871	B
UNIVERSITY OF RHODE ISLAND Kingston Rhode Island 02881	B, M

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SCHOOL	LEVEL*
South Carolina	
CLEMSON UNIVERSITY	D
Clemson	
South Carolina 29631	
FLORENCE-DARLINGTON TECHNICAL COLLEGE	A
Florence	
South Carolina 29501	
GREENVILLE TECHNICAL COLLEGE	A
Greenville	
South Carolina 29606	
MIDLANDS TECHNICAL COLLEGE	A
Columbia	
South Carolina 29202	
PIEDMONT TECHNICAL COLLEGE	A
Greenfield	
South Carolina 29646	
SPARTENBURG TECHNICAL COLLEGE	A
Spartenburg	
South Carolina 29303	
YORK TECHNICAL COLLEGE	A
Rock Hill	
South Carolina 29730	
South Dakota	
Tennessee	
CLEVELAND STATE COMMUNITY COLLEGE	A
Cleveland	
Tennessee 37311	
JACKSON STATE COMMUNITY COLLEGE	A
Jackson	
Tennessee 38301	
NASHVILLE STATE TECHNICAL INSTITUTE	A
Nashville	
Tennessee 37209	
STATE TECHNICAL INSTITUTE AT MEMPHIS	A
Memphis	
Tennessee 38134	
TENNESSEE TECHNOLOGICAL UNIVERSITY	B, M, D
Cookesville	
Tennessee 38501	
TRI-CITIES STATE TECHNICAL INSTITUTE	A
Blountville	
Tennessee 37617	

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SCHOOL	LEVEL*
UNIVERSITY OF TENNESSEE-CHATTANOOGA Chattanooga Tennessee 37402	B, M
UNIVERSITY OF TENNESSEE-KNOXVILLE Knoxville Tennessee 37996	B, M
VANDERBILT UNIVERSITY Nashville Tennessee 37212	M
WALTERS STATE COMMUNITY COLLEGE Morristown Tennessee 37814	A “
Texas BRAZOPORT COLLEGE Lake Jackson Texas 77566	A
CENTRAL TEXAS COLLEGE Killeen Texas 76541	A
KILGORE COLLEGE Kilgore Texas 75662	A
SAINT MARY’S UNIVERSITY San Antonio Texas 78240	B, M
SOUTHERN METHODIST UNIVERSITY Dallas Texas 75278	B, M, D
TEXAS A&M UNIVERSITY College Station Texas 77843	B, M, D
TEXAS STATE TECHNICAL INSTITUTE Amarillo Texas 79111	A
TEXAS TECH UNIVERSITY Lubbock Texas 79409	B, M, D
UNIVERSITY OF HOUSTON Houston Texas 77004	B, M, D

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SCHOOL	LEVEL*
UNIVERSITY OF TEXAS-ARLINGTON Arlington Texas 76017	B, M, D
UNIVERSITY OF TEXAS-AUSTIN Austin Texas 78712	B, M, D
UNIVERSITY OF TEXAS-EL PASO El Paso Texas 78712	B, M
Utah UNIVERSITY OF UTAH Salt Lake City Utah 84112	B, M, D
WEBER STATE COLLEGE Ogden Utah 84408	B
Vermont	
Virginia NEW RIVER COMMUNITY COLLEGE Dublin Virginia 24084	A
VIRGINIA HIGHLANDS COMMUNITY COLLEGE Abingdon Virginia 24210	A
VIRGINIA POLYTECHNIC INSTITUTE & STATE UNIVERSITY Blacksburg Virginia 24601	B, M, D
Washington NEW COLUMBIA COLLEGE Longview Washington 98632	A
SHORELINE COMMUNITY COLLEGE Seattle Washington 98133	A
SOUTH SEATTLE COMMUNITY COLLEGE Seattle Washington 98106	A
SPOKANE COMMUNITY COLLEGE Spokane Washington 99207	A

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SCHOOL	LEVEL*
UNIVERSITY OF WASHINGTON Seattle Washington 98105	B
West Virginia SALEM COLLEGE Salem West Virginia 26426	B
WEST VIRGINIA NORTHERN COMMUNITY COLLEGE Wheeling West Virginia 26003	A
WEST VIRGINIA UNIVERSITY Morgantown West Virginia 25606	B, M
Wisconsin BLACKHAWK TECHNICAL INSTITUTE Janesville Wisconsin 53545	A
GATEWAY TECHNICAL INSTITUTE Kenosha Wisconsin 53140	A
GATEWAY TECHNICAL INSTITUTE-RACINE Racine Wisconsin 53403	A
MILWAUKEE AREA TECHNICAL COLLEGE Milwaukee Wisconsin 53203	A
MORAINES PARK INSTITUTE-BEAVERS DAM Beaver Dam Wisconsin 53916	A
MORAINES PARK TECHNICAL INSTITUTE-FOND DU LAC Fond du Lac Wisconsin 54935	A
NORTH CENTRAL TECHNICAL INSTITUTE Wausau Wisconsin 54401	A
UNIVERSITY OF WISCONSIN-MADISON Madison Wisconsin 53706	B, M, D
UNIVERSITY OF WISCONSIN-MILWAUKEE Milwaukee Wisconsin 53201	B

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SCHOOL	LEVEL*
UNIVERSITY OF WISCONSIN-PLATTEVILLE Platteville Wisconsin 53818	B
UNIVERSITY OF WISCONSIN-STOUT Menominee Wisconsin 54751	B, M
Wyoming	

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**SCHOOLS OFFERING DEGREES
IN
NAVAL ARCHITECTURE**

SCHOOL	LEVEL*
UNIVERSITY OF CALIFORNIA-BERKELEY Berkeley California 94720	B
UNITED STATES NAVAL ACADEMY Annapolis Maryland 21402	B
MASSACHUSETTS INSTITUTE OF TECHNOLOGY Cambridge Massachusetts 02139	B, M, D
UNIVERSITY OF MICHIGAN Ann Arbor Michigan 48185	B, M, D
STEVENS INSTITUTE OF TECHNOLOGY Hoboken New Jersey 07030	M, D
WEBB INSTITUTE OF NAVAL ARCHITECTURE Glen Cove New York 11542	B

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**SCHOOLS OFFERING DEGREES
IN
MARINE ENGINEERING**

SCHOOL	LEVEL*
CALIFORNIA MARITIME ACADEMY Vallejo California 94590	B
UNIVERSITY OF CALIFORNIA-BERKELEY Berkeley California 94720	B
UNITED STATES COAST GUARD ACADEMY New London Connecticut 06320	B
MAINE MARITIME ACADEMY Castine Maine 04421	B
UNITED STATES NAVAL ACADEMY Annapolis Maryland 21402	B
MASSACHUSETTS INSTITUTE OF TECHNOLOGY Cambridge Massachusetts 02139	B, M, D
UNIVERSITY OF MICHIGAN Ann Arbor Michigan 48185	B, M, D
SUNY-MARITIME COLLEGE Fort Schuler, Bronx New York 10465	B
UNITED STATES MERCHANT MARINE ACADEMY King's Point New York 11024	B
TEXAS A&M UNIVERSITY-GALVESTON Galveston Texas 77553	B
BRIGHAM YOUNG UNIVERSITY Provo Utah 84602	B, M

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